Engineering education development – a business modelling approach

Mirka Kans
Mechnical Engineering, Linnaeus University, Vaxjo, Sweden

Received 14 February 2020
Revised 8 May 2020
29 September 2020
Accepted 19 November 2020

Abstract

Purpose – The purpose of this article is to promote an innovative approach to education development projects by the application of business modelling tools and methods.

Design/methodology/approach – The proposed method is based on tools and methods from the business modelling area, such as stakeholder mapping, SWOT analysis, business modelling canvas and scenario analysis. The applicability of the approach is illustrated by a case study conducted on an engineering programme, where qualitative and quantitative data were gathered through interviews, surveys and workshops.

Findings – Utilising business modelling tools for development projects in higher education gives several benefits: (1) knowledge-informed decision making; the methods require good understanding of the current situation as well as possible strategies to be applied, that is data gathering is necessary before decision making; (2) structured decision making by applying a step-by-step approach for the development project; (3) including different stakeholder's perspectives in order to gain a holistic understanding and avoid sub optimisation.

Originality/value – The approach promotes innovation and action driven development rather than a bureaucratic and metric based improvement process. Tools and models from the business area have previously been applied for educational development. However, a holistic business modelling approach for educational development has not yet been applied.

Keywords Action research, Stakeholder analysis, Business modelling, Education development projects, Engineering education development, Qualitative and quantitative data gathering

Paper type Research paper

1. Introduction

Continuous evaluation and improvement of higher education is essential for assuring high quality and relevancy. According to Illeris (2004), the learning environment should be considered from its context as well as from a societal perspective. Thus, the educational design affects both those actively participating in the learning situation, mainly teachers and students, and those who benefit from it from a social perspective. These actors, together with actors who regulate and support learning (such as administrators) are the stakeholders of education (Kettunen, 2015). In particular, teachers and other academic staff with direct influence define the content and design of the education (Roberts, 2015), but an increased attention has been put on the external stakeholders and their requirements (Jonsdottir *et al.*, 2011; Kjaer *et al.*, 2017; Roffe, 2010; Keogh *et al.*, 2010). Especially for professional sciences, such as engineering, it is important to align the curriculum and education design with future competence requirements of the students (Yorke and Knight, 2007). The mode in which this has been done spans from textual analysis of standards and job descriptions (Kim, 2015) to

This work was funded by The Kamprad Family Foundation.

Higher Education Evaluation and Development
Vol. 15 No. 1, 2021
pp. 53-77
Emerald Publishing Limited
2514-5789
DOI 10.1108/HEED-02-2020-0003

involving stakeholders in Delphi studies (Jonsdottir *et al.*, 2011; Kjaer *et al.*, 2017) and interview studies (Roffe, 2010; Keogh *et al.*, 2010). Continuous improvement is closely connected with the quality movement based on the Plan-Do-check-Act approach (Asif and Raouf, 2013) and quality assurance models on organisational, national and international level. Numerous quality assurance models have consequently been adapted for higher education as well (Ryan, 2015), however, not without complications. Yingqiang and Yongjian (2016) point out the imbalance between power and responsibility as a disadvantage and propose shifting from quality assurance towards a quality culture, where stakeholders can act under mutual trust. Ryan (2015) concludes that there is no common quality assurance definition or model exists. According to Shore and Wright (2015), the high emphasis on metrics and measurement has a negative impact on individual level: self-managed and innovative employees turn into burnout, disengaged and distrusting employees.

For promoting innovation and action driven development rather than a bureaucratic and metric based improvement process, a business modelling approach for education development is applied in this paper. Tools and models from the business area have previously been applied for educational development, such as stakeholder analysis (Simms and Chapleo, 2010; Kettunen, 2015), SWOT analysis (Hargis *et al.*, 2014; Fonseca *et al.*, 2015), PRIMO-F and PEST (Bishops and Mabry, 2016) or the business model canvas (Rytkönen, 2015; Gaus *et al.*, 2016; De Langen, 2018). However, a holistic business modelling approach for educational development has not yet been applied. The aim of this paper is therefore to suggest such an approach. Different methods and tools support specific activities in the educational development process, but there are interdependencies between them as well; the output of one method could be served as input for another. Consequently, applying a holistic process perspective would allow an efficient utilisation of the tools and methods. The applicability of the approach is illustrated by a case study conducted on an engineering programme.

The paper is dispositioned as follows: in the next section dimensions of engineering education, which is the focus of this paper, are discussed. A model for educational development projects is proposed in section three. The method was developed as a part of an educational development project carried out at the Forestry and Wood Technology department at Linnaeus University. The project is introduced in chapter four, and an application example based on the same project is given. The post-project evaluation of the method is found in section five, and general conclusions are drawn in the last section.

2. Dimensions of engineering education development

Education development projects could target *what* to teach, that is content, *how* to teach, that is context, or a mix of both. The term educational context is often used for describing an educational system, for instance "the Swedish educational context". It could also refer to factors that affects the learning, such as teaching styles, curriculum content, and assessment methods (Ramsden, 2003). In this paper, the tem content will be used for reflecting *what* to teach, while contexts will be used to reflect *how* to teach. Content is thus manifested in the syllabus of the educational programme while context is manifested by the educational design. In the following, these aspects with respect to engineering education are discussed and exemplified.

2.1 The content of engineering education

The curriculum content is regulated by national governmental bodies specifying the expected learning outcomes, either in form of national accreditation systems such as in US and UK, or in form of quality assurance systems such as in Sweden (Armstrong *et al.* (2006)).

In US, the ABET criteria for Accrediting Engineering Programmes includes 11 general criteria for student outcomes (ABET, 2017). In Sweden, the education is regulated in the Higher Educational Regulation (Swedish National Agency for Higher Education, 1993). For the Bachelor of Science in Engineering, 11 learning outcomes are set. The accreditation in Canada is not based on expected learning outcomes, but on minimum curriculum components specified for Mathematics, Natural sciences, Engineering science, Engineering design and Complementary Studies, which includes societal and sustainability aspects as well as communication skills and professionalism (Engineers Canada, 2017). An overview of expected learning outcomes in the above mentioned countries are given in Table 1. It appears that the anticipated engineering skills are quite the similar and that traditional teaching and assessment in form of written exams are not enough for achieving the stated outcomes. Traditional teaching focuses on knowledge outcome; in todays' working life personal and interpersonal skills are required, in addition to the formal subject knowledge (Yorke and Knight, 2007). One cannot for instance train the ability to function in multidisciplinary teams or the ability to plan and carry out advanced tasks within specified time limits by reading a book and thereafter account for the knowledge during an exam.

For closing the gap between traditional engineering education and real-world demands, leading engineering schools from all over the world formed the CDIO Initiative; a worldwide collaboration to conceive and develop a new vision of engineering education to meet the demands of the next generation of engineers (CDIO, 2020). Today, CDIO comprise more than 140 members from all continents of the world. CDIO is an acronym for Conceive, Design, Implement, and Operate – the life cycle phases of a product or system. According to the CDIO initiative, engineering graduates should be able to conceive, design, implement and operate complex engineering systems in a modern team-based engineering environment. For specifying the necessary engineering skills, a comprehensive list of requirements has been developed in form of the CDIO syllabus (Crawley *et al.*, 2011). This syllabus, see Table 2, covers basic and deepened knowledge requirements, personal and professional skills, interpersonal skills and skills associated with the product life cycle expressed as conceiving, designing, implementing and operating a product, concept or process.

2.2 The context of engineering education

Decisions regarding length of study, distribution form and study pace affect the possibilities for a potential student group to participate in the education. For younger students, traditional full time campus-based teaching could be positive from a learning perspective, as it provides close proximity to teachers and other students, and the opportunity to create attractive physical learning environments. From the perspective of lifelong learning other conditions such as flexibility in time and space are more important (Sad *et al.*, 2014). For prospective students who have established themselves geographically and/or on the labour market distance learning and a lower study pace are important enablers. A modern educational institution has an interest in meeting the needs of different types of students that forms a heterogeneous education environment. Flexible learning in the form of online-based teaching, flipped classroom and student-centred learning is therefore seen by many as the future's learning (Gavin, 2010; Mirriahi *et al.*, 2015; De Hei *et al.*, 2015). For succeeding with distance-based education digital competence and the ability to utilise modern technology effectively in teaching and learning are prerequisites for students and teachers alike. Mirriahi *et al.* (2015) highlight the teachers' low technology maturity as an obstacle to mixed and online-based teaching methods, and De Hei *et al.* (2015) perceive the lack of time and formal methods as obstacles to creating effective collaborative learning. For engineering education additional hinders exists, such as how to handle practical activities like laboratory work and project work in an online or distance-based format.

ABET criteria for accrediting engineering programmes, US	Canadian engineering Accreditation board, Canada	Higher educational regulation for the bachelor of science in engineering, Sweden
An ability to apply knowledge of mathematics, science, and engineering	Mathematics: Minimum 195 AU Natural sciences: Minimum 195 AU	Demonstrate broad knowledge within the chosen engineering field and relevant knowledge of mathematics and science
An ability to design and conduct experiments, as well as to analyse and interpret data	Engineering science: Minimum 225 AU	Demonstrate the ability to apply a holistic view to independently and creatively identifying, formulating and handling issues as well as analysing and evaluating different technical solutions Demonstrate the ability to critically and systematically utilize knowledge as well as modelling, simulating, predicting and evaluating processes on the basis of relevant information
An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Engineering design: Minimum 225 AU	Demonstrate the ability to design and handle products, processes and systems, taking into consideration human conditions and needs as well as society's goals for economically, socially and ecologically sustainable development
An ability to function on multidisciplinary teams	Complementary Studies: Minimum 225 AU (c. Professionalism, ethics, equity and law, g. Engineering economics and project management)	Demonstrate the ability for team work and cooperation in differently composed groups
An ability to identify, formulate, and solve engineering problems	Engineering science: Minimum 225 AU	Demonstrate the ability to plan and use adequate methods to implement tasks within given frameworks
An understanding of professional and ethical responsibility	Complementary Studies: Minimum 225 AU (c. Professionalism, ethics, equity and law)	Demonstrate the ability to make assessments taking into consideration scientific, social and ethical aspects
An ability to communicate effectively	Complementary Studies: Minimum 225 AU (b. Oral and written communications)	Demonstrate the ability to present orally and in writing as well as discussing information, problems and solutions in dialogue with different groups
The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Complementary Studies: Minimum 225 AU (a. Subject matter that deals with the humanities and social sciences, d. The impact of engineering on society, e. Health and safety, f. Sustainable development and environmental stewardship)	Show an insight into the possibilities and limitations of engineering, its role in society and human responsibility for its use, including social and economic as well as general environmental and work environmental aspects

Table 1.
Expected learning outcomes for undergraduate engineering programmes, US, Canada, Australia and Sweden

(*continued*)

ABET criteria for accrediting engineering programmes, US	Canadian engineering Accreditation board, Canada	Higher educational regulation for the bachelor of science in engineering, Sweden
A recognition of the need for, and an ability to engage in life-long learning		Demonstrate the ability to identify their need for further knowledge and for continuously developing their competence
A knowledge of contemporary issues An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Engineering science: Minimum 225 AU Engineering design: Minimum 225 AU	Demonstrate knowledge of the scientific basis and tried experience of the chosen field of engineering as well as acquaintance with current research and development work

Table 1.

Skill group	Detailed skills
1. Disciplinary knowledge and reasoning	1.1 Knowledge of underlying mathematics and science 1.2 Core fundamental knowledge of engineering 1.3 Advanced engineering fundamental knowledge, methods and tools
2. Personal and professional skills and attributes	2.1 Analytical reasoning and problem solving 2.2 Experimentation, investigation and knowledge discovery 2.3 System thinking 2.4 Attitudes, though and learning 2.5 Ethics, equity and other responsibilities
3. Interpersonal skills: teamwork and communication	3.1 Teamwork 3.2 Communication 3.3 Communications in foreign languages
4. Conceiving, designing, implementing and operating systems in the enterprise, societal and environmental context	4.1 External, societal and environmental context 4.2 Enterprise and business context 4.3 Conceiving, systems engineering and management 4.5 Implementing 4.6 Operating 4.7 Leading engineering endeavours 4.8 Engineering entrepreneurship

Table 2.
The CDIO syllabus v. 2.0

The teaching context and how it is designed is important for effective learning, but in practice, it can be difficult to create effective learning environments due to restricted resources. Moreover, the design dimensions are often seen as contrasts, such as campus versus online or individual work versus collaborative work. The most obvious is perhaps the contrast between the traditional view of higher education, primarily teacher-centred knowledge sharing reproduced by the student, versus the trend of open, often online-based, learning situations where the teacher primarily acts as coach and the goal is knowledge creation rather than knowledge reproduction (Murray *et al.*, 2014; McLaren and Kenny, 2015). Instead, mixing these perceived contrasting design modes could be a factor of success.

The design of specific learning situations is linked to who is active; the student or the teacher. Practical elements of an education activate the student in first hand, while theoretical elements can be designed in a variety of ways, ranging from teacher-active to student-active learning environments. A learning environment that activates the student through practical tasks such as laboratory work, excursions, design and construction projects or other hands-on activities, have a positive impact on student learning (McDonald and Scott, 1994; Castles *et al.*, 2009). Another dimension of educational design is the type of knowledge that is created during the education; consolidation of the known or innovation and creativity. Cropley (2015) connects the need to change engineering education with a changing world. When the world changes rapidly, creative problem solving skills are needed (we learn to solve new problems, we learn to find new strategies to solve problems) as a complement to problem solving where one or more variables are known (we learn to solve a known problem, or we will learn to solve a new problem through a known strategy).

Yet another aspect is the perspectives put on the educational context. There are a number of perspectives that can and should be adopted: internationalisation (Wamboyle *et al.*, 2015), globalisation (Chung, 2011) or social, economic, social and environmental perspectives, termed sustainability (Christie *et al.*, 2015; Schmitt Figueiro and Raufflet, 2015), to name a few. Internationalisation is often linked to recruiting international students and its acclimatisation into the host country, and not how to handle internationalisation in the actual content of education (Patel and Lynch, 2013). Instead, you can talk about local (national) or global (international) values. Patel and Lynch preface the term glocalisation, which connects local and global values.

3. Education development based on business modelling: the INT-EXT method

The INT-EXT method, see Figure 1, was developed as a part of the project described in the next section. It is based on a knowledge-informed and design-oriented approach for problem solving in organisations (van Aken *et al.*, 2012), in the area of action research. The method describes a knowledge-informed step-by-step process for education development projects that utilises well-known models and methods from the business modelling area as well as scientific data gathering methods. Steps one to three describe data gathering activities, step four analysis activities, and step five further action planning. As indicated by the abbreviation, it covers both the internal (INT) and external (EXT) conditions. The internal conditions refer to conditions within a specific educational context on programme, department, faculty or university level. External conditions refers to conditions outside the educational context, such as competitors, laws and regulations or markets.

As a starting point, a problem or opportunity is defined, such as poor application rates or possibilities to develop new programmes to meet an emerging demand. The first step, *Stakeholder analysis*, aims at identifying the most important stakeholders and their interrelationships. Identifying the stakeholders early on in the project is beneficial of several reasons; it supports the selection of actors to include as respondents in the survey, but also actors that are powerful or important, and thus might be necessary to include as an active part in the development project for its success. According to a study by Simms and Chapleo (2010), the most common stakeholder groups are students (prospective, current and alumni), local and national businesses, and university staff (academic and non-academic). The identification is easiest made by listing different internal as well as external stakeholders, while the interrelationships are described graphically using a stakeholder map (Figure 2), or the similar. Internal stakeholders comprise students, teachers and administrators, but also decision makers at the university. External stakeholders are for instance companies, governing bodies, other universities (could be seen as competitors as well as collaborators), alumni, prospective students such as high school students or even parents. Finally, actors to

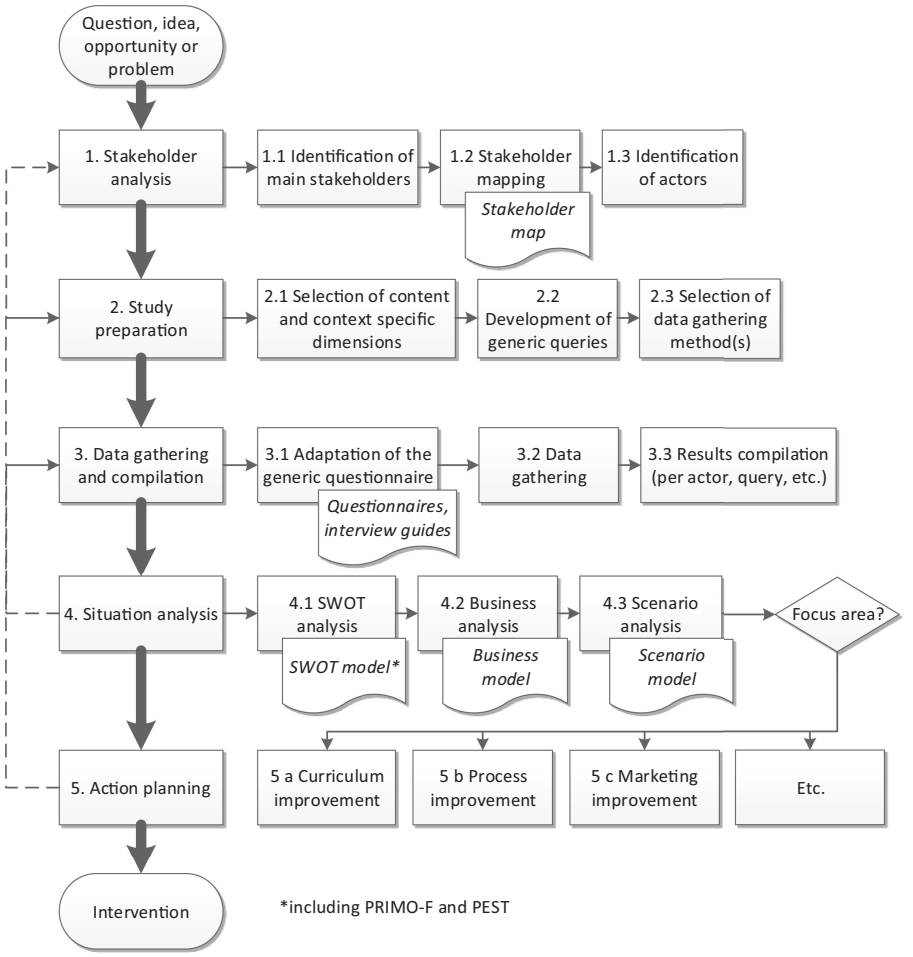

Figure 1.
The INT-EXT method

include in the further investigation are selected. While stakeholders are generic objects such as teachers, students and alumni, actors represent real objects connected to a specific programme, such as high school students from the three closest schools, alumni from the years 2000–2005 or all teachers actively giving courses at the programme.

Next step, *Study preparation*, aims at designing the data gathering. This step enables structured data gathering that will effectively support further analysis, and thus ensure that the whole process is focused on solving the stated problem. Areas to include in the investigation are decided and translated into generic questions reflecting the queries to be done. The data gathering could cover a number of other areas, such as education content and context, examination forms, or perspectives in the education. The questions may be directed towards a particular area, such as entrepreneurship or sustainability. Also, data gathering methods are chosen, such as questionnaires, interviews, focus group discussions, Internet searches, or gathering of statistics. In step three, *Data gathering and compilation*, the generic questions are adapted for the specific data gathering methods chosen before the investigations are conducted. Qualitative and quantitative results from the data gathering

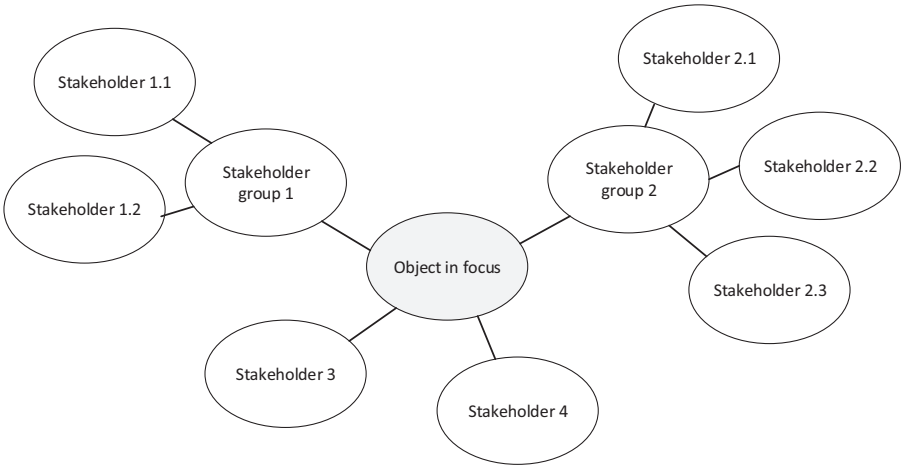

Figure 2.
Stakeholder map

are compiled for each question, actor group and/or based on internal or external conditions. The compilation of data eases the mapping and analysis activities in the next step.

Step four, *Situation analysis*, aims at deeper understanding of the current situation. In the INTE-EXT model three types of analyses are suggested: SWOT analysis for understanding strengths and weaknesses, opportunities and threats, business analysis for understanding the value proposition and scenario analysis for developing action plans. These methods were selected because of they are relatively easy to learn and apply. Other models, tools and methods could be utilised as well depending on the nature of the development project. The methods are briefly explained below.

SWOT is an English acronym that read out as "Strengths", "Weaknesses", "Opportunities" and "Threats". SWOT analysis is a tool that can be used for mapping the current status of a business. The analysis thus provides valuable input for business strategy development (Kotler *et al.*, 2017). The results of a SWOT analysis is in the form of a matrix, where positive and negative aspects of the investigated area are documented, see Figure 3. The matrix is divided into four fields representing strengths/possibilities as well as weaknesses/threats. The internal aspects are strengths, for instance market position, products and innovations, processes, skills and resources that the business possesses, as well as weaknesses, that is capabilities the business does not possess or manages in a poor way. The external aspects are opportunities and threats such as market trends, economic trends,

	Positive	**Negative**
Internal	Strengths People, Resources, Innovation & Ideas, Marketing, Operations, and Finance	Weaknesses People, Resources, Innovation & Ideas, Marketing, Operations, and Finance
External	Opportunities Political, Economic, Social, and Technological	Threats Political, Economic, Social, and Technological

Figure 3.
SWOT matrix

financing, relationships with other actors, as well as political, environmental or financial regulations. As a first step in a SWOT analysis, information is gathered from internal and external sources. The information is thereafter sorted into the SWOT matrix.

The internal factors could be grouped according to the PRIMO-F model, which describes important internal resources. PRIMO-F is an acronym for People, Resources, Innovation & Ideas, Marketing, Operations and Finance. For the external factors, the PEST model can be used. PEST describes four macro-factors that affect a company or organisation: political, economic, social and technological. Political factors include tax rules, trade laws and political stability. Economic factors include for instance inflation rates, growth rates and economic cycles. Social factors include social and cultural factors such as security, education and fashion trends. Technological factors reflect the technological development. SWOT analysis is used for understanding the current situation for the object in focus for the development project, as well as possibilities in the future.

Business models describe how a company creates, delivers and accrues value (Osterwalder and Pigneur, 2010), comprising elements such as strategy, customer relationships, market segments and value-creating mechanisms. The business model canvas is a tool proposed by Osterwalder and Pigneur (2010) for developing new business models, or for documenting existing business models. The canvas describes the internal as well as the external capabilities necessary in order to create a specific value proposition, that is a business opportunity, see Figure 4. Business analysis is used for understanding the value that is provided by the object in focus for the development project, and how the value best could be produced and distributed.

The purpose of a scenario analysis is to describe and analyse possible futures, and create deeper understanding of different actions that could be taken, both conventional and "wild cards", that is more unlikely events. Scenario analysis is based on the known facts as well as on forecasting and imagining the future. Several different scenario methods and models

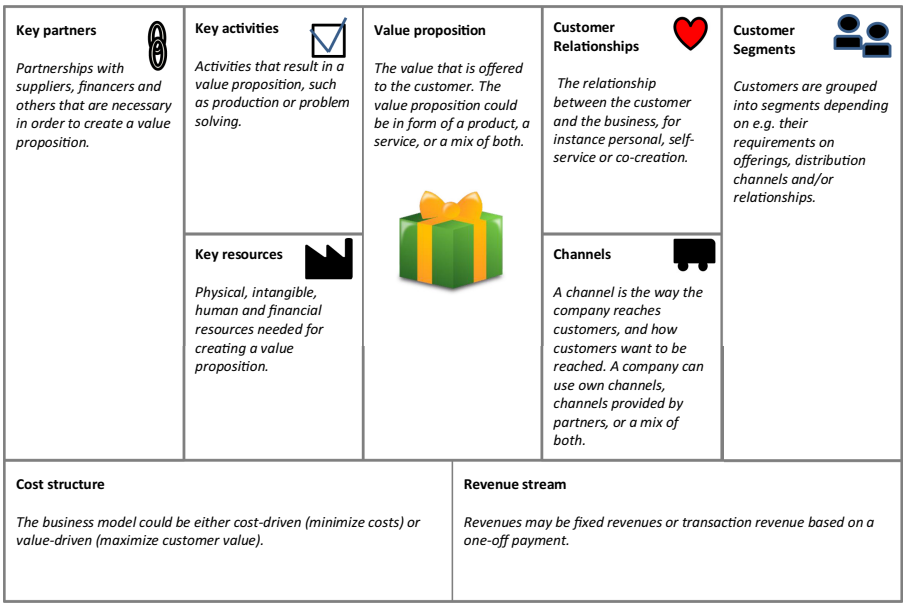

Figure 4.
Business model canvas

exists, depending on the aim and context of the analysis. A general process for a scenario analysis is (Beecroft and Schmidt, 2014):

(1) Define a future related question or desired future state,

(2) Describe the current state,

(3) Develop a set of scenarios describing the future state,

(4) Describe paths and time lines for reaching each scenario,

(5) Analyse the set of scenarios, and

(6) Give recommendations.

The INT-EXT method covers all the included steps in a scenario analysis, utilising the SWOT and business model canvas techniques for describing the current situation.

In the final step of the INT-EXT method, *Action planning*, the further work is decided and planned. From the situation analysis one or several areas of improvement are selected, such as curriculum development, internal process improvement, marketing activities, organisational improvement or course execution improvement, to mention a few. In case several development areas are selected, the ranking of sub-projects might be needed. Ranking could be done according to technical, organisational and economic feasibility or using the Pareto principle that 80% of the effects come from 20% of the causes, i.e. start with the single improvement that gives largest impact. The action plan defines what to do, when to do it (or when to be finished), who is involved in the process and who is responsible, as well as how the work should be done.

4. Application example

In this section, experiences from an education development project are used for illustrating the application of the INT-EXT method. First, the project context and the needs for educational development is described. Thereafter, the step-by-step description of the project is given according to the structure of the INT-EXT method.

4.1 Project description

The case project targeted educational programmes at the Forestry and Wood technology department (SoT) at Linnaeus University (Lnu). The department offers courses and programmes that cover the entire value chain from forest to finished wood-based product, and wood as material is a common theme in the education. Two undergraduate programmes, a bachelor's programme and a bachelor of engineering programme, and one master's programme constitutes the programme offer. In addition, distance-based courses in sustainable small-scale forestry equivalent to more than 90 credits are offered. The bachelor's programme is given only in distance form, while the bachelor of engineering programme and the master are offered both as a campus and distance option. While the bachelor's programme has no recruitment problems, the engineering and master's programmes struggle with low application numbers. A project was therefore initiated to further develop the engineering and master's programmes. The overall objective was to review the programmes for quality enhancement, and to investigate possibilities to increase and stabilise the future recruitment for the targeted programmes. To achieve this, it was considered as important to gain a deep understanding of the external as well as the internal conditions:

(1) What are the external conditions? (Questions such as: "What target groups are there?", "What other educational programmes are given within the area?", "What is the

demand for such programmes?", "What do industry and alumni find important to cover in training?")

(2) What are the internal conditions? (Questions such as: "What are the strengths and weaknesses of the current programme?", "What do teachers and administrators find important to cover in training?")

The study used a design driven and knowledge-informed action-based approach (van Aken *et al.*, 2012). Data collection has taken place in several iterations, as the results from a survey gave rise to new questions that had to be answered. The focus has been understanding and dialogue – to constantly understand a little more by gathering more information and hearing those who work closest to the questions. In the first iteration, programme students and alumni answered questions regarding education content as well as education design. Interviews with teachers and administrative staff to address the strengths and weaknesses of the engineering programme were also made. In the next iteration, prospective students were asked, during an education fair, how they want education to be designed, and focus group discussions regarding education contents and design were carried out with teachers and administrative staff. The study was thereafter extended with business representatives' perspectives on education content and education design, as well as interviewing students regarding information contents and page design of the departments web pages used for educational marketing. In parallel with this work, the activities within the department have been mapped out from a business perspective. A circular process was applied, allowing us to move between the holistic level and the detailed level, in order to understand the core business situation, such as courses and their layouts, education programmes and their syllabuses, as well as the entire education offer and its position in the business ecology. A third parallel activity has been to describe what entrepreneurship means for the subject of forestry and wood technology, and how to work with entrepreneurship in the education programmes. The descriptions in this paper are delimited to the data gathering for the central questions at hand, namely educational contents and design, and for the situation analysis. These data gathering activities were also the ones that followed the most straightforward process according to the INT-EXT method.

4.2 Step 1: stakeholder analysis

As a first step, different internal and external stakeholders were identified, listed and mapped. The identification was made in a brainstorming session together with responsible persons for education at the department. Table 3 exemplifies how the stakeholder identification process was carried out and documented. The stakeholder in the example is potential students, and three different sub-groups are found under this category; pupils in high school, which is the largest and most important group, students enrolled in foundation

Potential students, engineering programme	Things to consider	Identified actors
Pupils in high school	Which geographic area What programmes?	Pupils at the high school information day
Other groups, such as Folk high schools and other adult education	Review previous year's admission, are students recruited from this group?	
Students on foundation year/ semester	Only Linnaeus University?	Foundation year/semester at Linnaeus University
Professional workers in the subject area	Is there any interest in taking an engineering education?	Industry representatives in the programme council, alumni

Table 3.
Example stakeholder list, potential students

year/semester studies, and people currently working in industry that are willing to learn more, or to certify existing knowledge. The foundation year or semester is an education form often located at the universities that gives the opportunity for persons without formal eligibility to achieve eligibility in natural science or engineering related higher education. In some cases, the students are offered a number of reserved places in the higher educational programmes at the university in which they complete the foundation year in. For each sub-group, specific interest parts were identified that would suit the specific characteristics and needs of the project.

The stakeholder relationship was described in a stakeholder map. Figure 5 describes stakeholders for the Bachelor of engineering programme. On the left hand side internal stakeholders are found: students at the programme and the student union, teachers that are directly or indirectly connected to the programme, administrators, and authorities. The latter stakeholder is both internal and external. The internal are in form of governing bodies at Linnaeus University, such as the Educational Council, while the most important external is UKÄ, The Swedish Higher Education Authority. Other external stakeholders are potential students, industry and other educational institutions that are collaboration partners or competitors with Linnaeus University. The stakeholder map in Figure 5 is a rather simple map, but some complexity is seen especially regarding alumni. Alumni are persons that finished the education and could be seen as an own category of stakeholders, but in this project they were mainly representing the industry perspective on competence needs, and therefore they were placed under the stakeholder industry.

4.3 Step 2: study preparation

The next step is preparing the data gathering from the identified actors and other sources of information. For this study, questions about education contents and education design were central and constituted the basis for data gathering from the stakeholders, such as potential students, current students, alumni, industry representatives, teachers and administrators. A generic set of queries was developed based on the CDIO syllabus and findings from a literature review regarding education design, see Table 4. In addition, a set of questions was developed based on the SWOT and PESTanalyses regarding the programme's strengths, weaknesses, opportunities and threats, see Table 5. Data gathering methods were thereafter decided.

The generic questions were thereafter adapted to the data gathering context and the type of actor included in the study. Two main aspects have been taken into account when adjusting the questionnaire in this study: proximity to the actor as well as depth in the answers. Many actors were spread geographically, such as business, alumni or high school students. Other actors are relatively close, especially teachers and other university staff. Great emphasis was put on being able to conduct the survey directly with the actors, i.e. face-to-face as far as possible. This proved possible for all actors except alumni and programme students. The alumni were geographically dispersed and no alumni-related activity was planned during the period of the survey. It turned out that the students also were dispersed at this time, as they completed graduate work and internship during the period. For these actors, a web-based survey was designed which posed questions about educational content and design, and for alumni additional questions about their experiences about the completed education. For pupils in junior high school a simple paper-based questionnaire was designed to be handed out during the annual information day. Students at the foundation year were taking a similar questionnaire during a regular class. The questionnaire was supplemented with questions regarding formal requirements and interest in reading the education. For three actors, industry representatives, teachers and administrators, the opportunity for deeper understanding of the issues in the form of focus group discussions was possible. For this purpose a questionnaire and a template for compiling qualitative results were

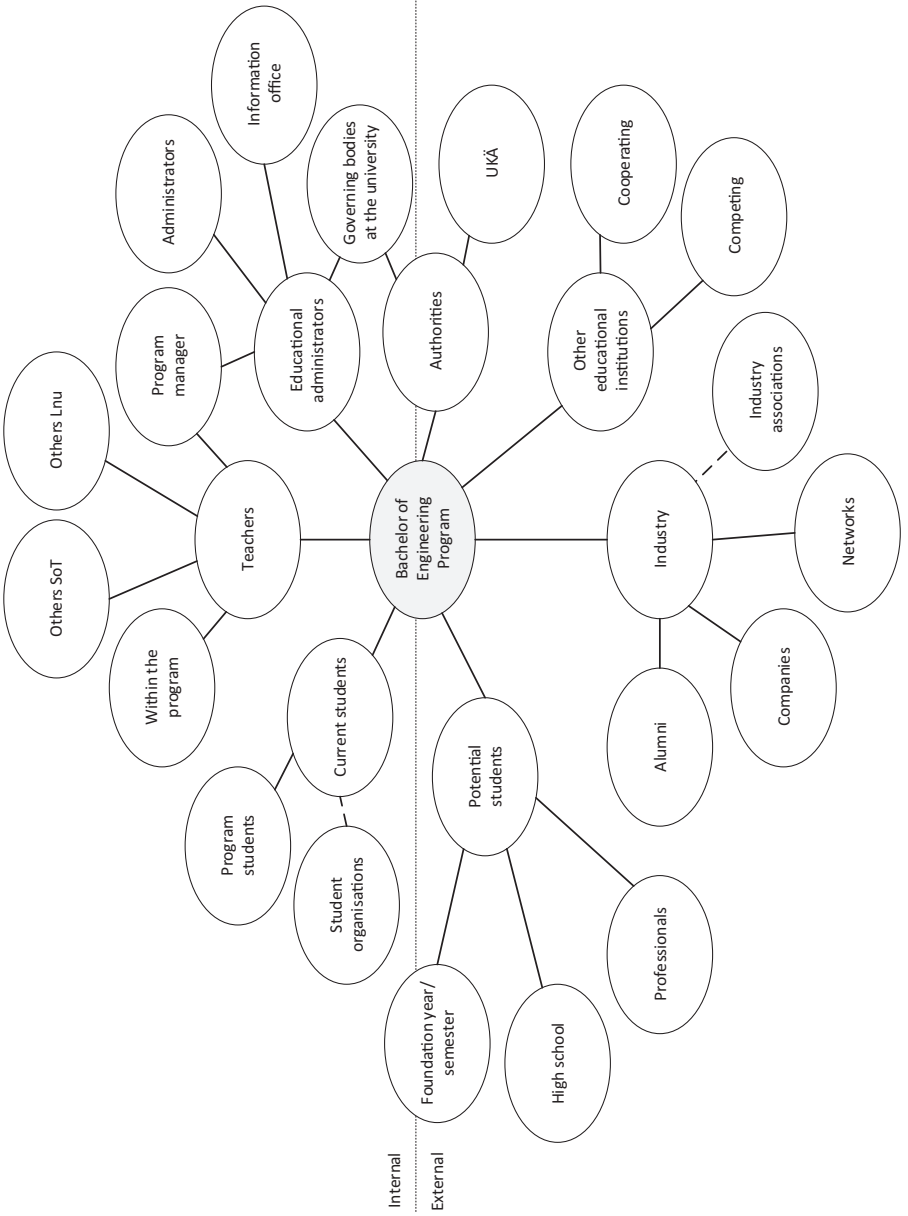

Figure 5.
Stakeholder map for the Bachelor of Engineering programme

1. Which areas of knowledge are most important for an engineer within Forestry and Wood Technology?	1.1 Mathematics and natural sciences 1.2 Societal and sustainability aspects 1.3 Other engineering subjects 1.4 Forestry 1.5 Forestry planning 1.6 Forest fuel knowledge 1.7 Material science 1.8 Wood related industrial engineering 1.9 Wood related industrial manufacturing 1.10 Construction engineering 1.11 Wood related business administration *Open questions* 1.12 Which areas of knowledge are most important? 1.13 Which are least important? 1.14 Is there anything in the list that should not be included? 1.15 Is there anything that should be included in the list?
2. Which competencies are most important for an engineer within Forestry and Wood Technology?	2.1 Analytical reasoning and problem solving 2.2 Experimentation, investigation and knowledge discovery 2.3 System thinking 2.4 Attitudes, though and learning 2.5 Ethics, equity and other responsibilities 2.6 Teamwork 2.7 Communication 2.8 Communications in foreign languages 2.9 External, societal and environmental context 2.10 Enterprise and business context 2.11 Conceiving, systems engineering and management 2.12 Implementing 2.13 Operating 2.14 Leading engineering endeavors 2.15 Engineering entrepreneurship Open questions 2.16 Which areas of knowledge are most important? 2.17 Which are least important? 2.18 Is there anything in the list that should not be included? 2.19 Is there anything that should be included in the list?
3. What are important characteristics of an engineering education within Forestry and Wood Technology?	3.1 Length of education: 1 year up to 5 years 3.2 How the education is distributed: Campus or distance 3.3 Pace of education: full speed down to quarterly speed 3.4 The percentage of compulsory courses: high percentage or low 3.5 Ratio of theory and practice 3.6 Influencing factor: university or industry 3.7 Perspective in education: global or Swedish conditions 3.8 Learning situation: Knowledge sharing or student-active learning 3.9 Individual work or cooperation 3.10 Knowledge outcomes: consolidation of knowledge or innovation

Table 4.
Questions regarding educational contents and design

created. In addition, a number of in-depth interviews were planned with teachers. Table 6 summarises the data collection methods used in the study.

4.4 Step 3: data gathering and compilation

Step number three concerns the gathering and compilation of data. In this study, primary data was gathered using three main methods; questionnaire survey, focus group discussion and interviews (see Table 6). Mixing qualitative and quantitative data increases the insights and understanding that might be missed when only a single method is used (Johnson *et al.*, 2007). In addition, several surveys in secondary data sources were conducted, such as in admission statistics databases, national university websites, studies conducted by industry association, and in previous research in form of literature reviews. These secondary data gathering activities are, as mentioned in section 4.1, not described in the further text.

4.4.1 Questionnaires. In total five questionnaire variants were developed; three paper based and two web based. The web-based survey was created in the software Survey & Report, which also supported the distribution through email. A four point Likert scale (1–4) was used for questions regarding education contents both for the paper based and web based questionnaires. The value 1 represented the choice "not important" and 4 the choice "very important". The education design questions were expressed in form of dualistic opposites. This is a conscious choice; to put concepts and phenomena in contrast to each other could help in clarifying that a contradiction does not exist. In the web-based survey the response options for the ten opposing pairs were on a scale between one and nine. If a respondent was strong for the first option, the value was 1, and the preference for the second option was 9. If the respondent had no specific preference, the middle option was chosen, the value 5. In the paper variant, the respondents were allowed to take a stand on the questions on a floating scale. The scale was then translated into a nine-digit scale. The design of the questionnaires naturally differed depending on target group and distribution form.

How familiar are you with the programme?
What strengths does the programme have?
What weaknesses does the programme have?
What opportunities does the programme face?
What threats you see the programme may face?

Table 5.
SWOT related questions

Actor	Method	Scope
Pupils in high school	Paper based survey	Questions regarding educational design, eligibility and interest in taking the programme
Students on foundation year	Paper based survey	Questions regarding educational design and interest in taking the programme
Programme students	Web based survey	Questions regarding educational contents and design
Teachers	Focus group discussion	Educational design
	Interviews	SWOT/PEST questions
Administrators	Focus group discussion	Educational design
Alumni	Paper/web based survey	Questions regarding educational contents and design, and perception of the programme they finished
Industry representatives	Focus group discussion	Questions regarding educational contents and design

Table 6.
Data gathering methods

Table 7 summaries the responses. The number of responses is in first sight rather low, but taking into account the response rate, a decent coverage of the actors except the alumni was reached. One plausible reason for the low response rate for alumni was outdated address information; the missing respondents might not have received the questionnaire at all.

The median values were used for the quantitative data analysis. This is because the scale is not necessarily perceived as an interval scale (with the same difference between each step on the scale) by the respondents, making the mean values misleading. An example of the compilation of data from the study is found in Figure 6. The example illustrates the answers on education contents from the student questionnaire, corresponding to the generic questions 2.9 to 2.15 in Table 4.

4.4.2 Focus group discussions. Two paper based questionnaire forms were designed in order to support the focus group discussions. The questions regarding education contents were formulated as open ended questions (unlike the questionnaires where a four-point Likert scale was used): "please note the competence or competencies you find most important, and thereafter note which, according to you, that are least important". For the education design questions, a floating scale was used.

Two focus group discussions were held: one with industry representatives during a reference group meeting (six participants from industry) and one with teachers and administrators during a regular meeting at the Forestry and Wood Technology department (ten participants). The discussions were led by the project manager, which also took notes and compiled the material. Participants were first asked to individually note their preferences on a separate form. Thereafter a discussion in the group was held. The individual responses were collected after the meeting and compiled together with the notes of the discussion.

4.4.3 Interviews. Eight semi-structured interviews were conducted with seven teachers and one administrative person using the questions found in Table 5. Five of the teachers were from the department of Forestry and Wood technology and two from other departments, but

Actor	Number of responses	Response rate	Female/male ratio	Median age
Pupils	34	N/A	14/20	18
Students on foundation year	13	68%	3/10	21
Programme students	15	39%	3/12	22.5
Alumni	28	19%	6/22	35.5

Table 7.
Summary of responses

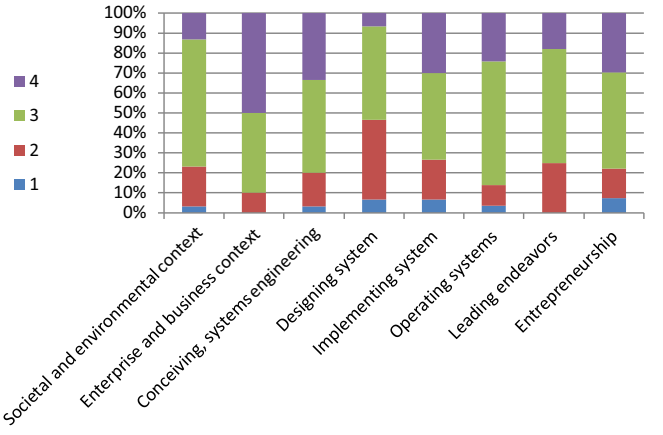

Figure 6.
Data compilation example

actively teaching one or more courses at the engineering programme in focus. The interviews were transcribed and used directly as an input to the SWOT analysis described in the next section.

4.5 Step 4: situation analysis

The situation analysis comprised four activities; SWOT analysis, business analysis, scenario development and analysis, and a half-day workshop where the findings were discussed and decisions regarding further directions were made. The SWOT analysis, see Figure 7, highlighted the current situation as well as future possibilities. Amongst the strengths with the engineering programme were the closeness to the industry (students were conducting several projects in collaboration with industry, including internship and guest lectures from industry were common), engaging and competent personnel, the distance based learning option, in addition to campus based entry, closeness to teachers and researchers within the subject area, and employment opportunities (the industry demand for the specific competence is high). The most dominant weakness was low enrolment in the programme; without a sound student base the income was affected, and some of the means to cut costs were hard to accomplish due to low level of inter departmental collaboration. The distance based version of the programme faced problems with the distribution form, such as teachers not confident in giving lectures online, facilities that are not suitable for online lectures, or problems with including laboratory work in the course.

The focus on wood as a sustainable material as well as the regional positioning of the programme were opportunities identified that could be used for marketing purposes. The distance based learning gives opportunities for lifelong learning, which could be used for

Strengths	Weaknesses
People: Interested students, active and closeness to teachers, good management **Resources:** nice facilities, subject competence, closeness to industry, other faculties and research **Innovation:** distance based learning, closeness to the forest and industry, value chain thinking **Marketing:** uniqueness, employment opportunities **Operations:** small group sizes, collaboration with industry and other education programs, high quality courses	**People:** Few students, few women, teachers with technology and ITC competency lacking, priority problems **Resources:** facilities not equipped for distance learning, too low collaboration with other faculties, priority problems **Innovation:** low level of internationalisation **Marketing:** uniqueness gives vagueness, hard to compete with well-established institutions **Operations:** collaboration education programs affects the curriculum design, too practical courses, laboratory work problematic on distance **Economy:** few students, affects the income
Opportunities	Threats
Political: internal support, education quality initiatives (CDIO, "the yellow thread") **Economic:** labour market, few competitors, big investors like IKEA and Kamprad, coordination possibilities with other education programs **Social:** wood as material, sustainability, entrepreneurship, south Swedish positioning, affect media and lobbying **Technological:** distance based education, lifelong learning	**Political:** results from national quality audits, engineering not in focus at the university, students from high school not always directly qualified for engineering programs **Economic:** few students, high level of fixed personnel costs for covering subjects in the full value chain, competition **Social:** trends, few applicants to technical educations in general, ambitious students apply to other programs

Figure 7.
SWOT analysis, the Bachelor of Engineering programme

attracting people already on the labour market. The economic opportunities were for instance the strong labour market and few competitors, making it feasible to increase the number of students on the programme and provide them with future work possibilities. Big regional investors could be used to attract students, but also for supporting educational development projects. Threats were seen in the political and societal dimensions on national and university level. The engineering education is one of many at Linnaeus University, which makes it hard to compete with the well-established technical universities in Sweden, but also with Swedish University of Agricultural Sciences (SLU) that has agricultural and environmental focus. This creates a tough competition, as there are too few applicants to engineering programmes on a national level. In addition, economic constraints might affect the quality of the programme, and a decision to cancel the programme due to inability to achieve quality goals could be a possible result.

For gaining better understanding of the results of the SWOT analysis, a half-day workshop with managers at the department was conducted, in which a business model for the engineering education was developed. The results are shown in Figure 8 (financial dimensions were not included). The value proposition was identified as providing engineering education that could be described by seven characteristics:

(1) *Providing education that is attractive by industry*. Students who finish the programme are offered employment in relevant positions.

(2) *Close connection with industry*. The programme includes several interactions with industry in the form of guest lectures, study visits, case studies and internship. The students thus acquire a large network during the studies.

(3) *Sustainability focus*. The education addresses sustainability, for instance in the form of wood as a sustainable material.

(4) *Niched education*. The education is unique; similar programmes do not exist nationally.

(5) *Knowledge informed*. The education is based on current research, and closeness to researchers.

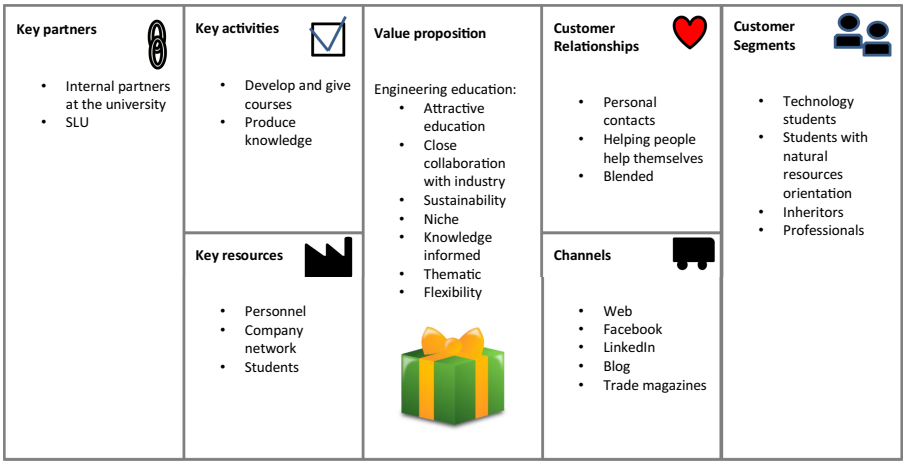

Figure 8.
Business model, the Bachelor of Engineering programme

(6) *Thematic education*. The programme covers the whole value chain, "from plant to plank".

(7) *Flexible distribution forms*. The programme is offered both as a campus based version and as a distance based version.

Key activities identified were developing and giving courses (i.e. the context dimension of the programme), and to create knowledge (i.e. the content dimension of the programme). Personnel was identified as the most important resource. Other key resources identified were students, because they affect the education for instance by being motivated and active during the knowledge creation, and the extensive network of industry representatives that the department possesses. Key partners were found internally such as teachers from other departments, and externally, such as the Swedish University of Agricultural Sciences (SLU) that is niched towards sustainability and biological natural resources. Within education, the main customers are the students. According to Osterwalder and Pigneur (2010) customers could be segmented into groups if their needs justify a distinct offer, if they are reached through different distribution channels, or if they require different types of relationships. Four student groups were identified. The first, technology students, are students who recently finished a technology programme at upper secondary level. They are interested in the engineering aspects of the programme and quite young, typically under 25 years. One driving force for this student group is to become attractive at the labour market, thus focusing on the characteristics "attractive education" and "close collaboration with industry". Another customer group comprises students with specific interest in the natural resources aspects of the programme. This student group is also quite young and mainly comes from an agricultural programme at upper secondary school level. They do not have the formal prerequisites for the programme, but must take a one-year preparatory course before entering the programme. Attractive programme characteristics are "close collaboration with industry" and "sustainability focus". These two student groups prefer campus based education, and value the personal contacts between teachers and other students. The main marketing channels for these groups are the university website or social media such as Facebook or the department blog.

Inheritors, i.e. persons that will inherit forest properties or the family owned sawmill, comprise the third student group. The age of this student group varies; some are young people soon to take over the business. Yet others have already been involved in the business for a while. These students are attracted to the distance-based version, but also to the campus-based version, if they live close to the university. The possibilities to mix and take the programme with a blended setup is also attractive. This student group is attracted to characteristics such as "niche", "knowledge informed", "thematic" and "flexibility". The fourth student group are professionals, that is persons that already entered the labour market. Typically, they seek a distance based education programme as they are already established themselves at a location, and are unwilling to move in order to study. "Flexibility" is therefore an attractive characteristic. Most often, they already work within the wood engineering area and would like to learn more and validate their knowledge. "Niche", "knowledge informed" and "thematic" are attractive characteristics. These students are often older and require less personal contacts with teaching staff. The teachers mainly support these students in helping themselves through the course websites. Trade magazines, LinkedIn and the blog are suitable marketing channels for the third and fourth student group.

Two scenarios were developed for the engineering programme, one focusing on offering a campus based version and one focusing on offering a distant based version (today both options are available, so the scenarios highlighted the possibilities of each distribution model separately). For both scenarios, actions required in the form of curriculum development,

marketing plan development, as well as for managerial/process development were found. It was decided that the mixed delivery, that is that the programme will be offered both as campus-based and distance-based version, would be the best option in short term. In long term, the distance-based version seems to have better possibilities from a recruitment perspective.

4.6 Step 5: action planning

Within the area of curriculum development actions were planned and carried out to adjust the content to better fit the engineering skills' and future labour market requirements. The programme content was mapped using the CDIO syllabus. The mapping revealed poor correlation between content and assessment for several skills; these skills were introduced or taught, but were not assessed in the course examination. Other necessary engineering skills, according to the CDIO syllabus, were not taught in any of the compulsory courses. Changes in the curriculum were made based on the mapping. A course in leadership was added as compulsory, and several changes in existing courses were made. In the course wood Manufacturing for instance, a business modelling exercise was added that trains the creative thinking and problem solving abilities, and the understanding of enterprise and business context was better highlighted in the internship course by adding a written reflection and including these aspects in the oral seminar. The mapping also revealed that some courses were not adapted for distance-based learning, and actions in order to transfer these course were taken in form of dialogues with the departments in charge of the courses.

Within the area of marketing several actions were planned and carried out, such as arranging a programme day for prospective students, focused marketing to students that has chosen the programme in first and second hand, and reformulation of programme descriptions on the web, for instance by adding information regarding the future labour market and by describing the thematic setup rather than single courses.

In addition, a change of programme manager was planned, as the existent manager soon would be retired. Valuable experiences as well as networks were transferred to the new programme manager. Closer collaboration with key partners, both internal at the university and external, was also planned for.

5. Post-project evaluation

A post-project evaluation was made in the form of a semi-structured interview with the head of the department, the head of education at the department and one of the programme managers. Two programme managers were involved in the project, but one of these had retired before the evaluation occurred, and could thus not participate. The interviews were performed by the project manager through a video conference system. After a brief introduction, in which the objective of the interview was described and a summary of the project was given, a discussion covering three main topics followed. The topics of the interview were:

(1) Reflect on the project process and the different methods and tools used. Was the process and the methods/tools efficient? Which methods/tools did you like best, and which did you not like?

(2) Reflect on the results of the project. What did the department and you learn? Were the results useful? Did you miss any results?

(3) Reflect on the effects of the project. Have you changed your way of working? Has the department changed in any way?

The respondents described a number of positive aspects with the project and the INT-EXT method. One strength is the knowledge-informed inquiry. Applying tools such as the ones in the INT-EXT method is beneficial, because you might know the answers intuitively but cannot describe how to reach them. The process results in extensive material to work with and a holistic view on the education. In addition, all the perspectives and comments you gather with the process, the uncomfortable truths, are major strengths. The holistic approach makes the SWOT analysis grounded in knowledge; otherwise the results loses credibility. Without a solid basis, the results are not validated and thus loses their usefulness. You might miss several important aspects if the work is not thoroughly done. Another strength is the structured process, as one respondent said: "The whole process, all the steps and all the analyses. You should always have a plan for how to proceed, and how to make use of the potential for development. It was really a solid work, and still relevant even some time after the project finished. I recall quite easily what we did during the project. The method makes it easy to do it once again; you can just start the process whenever". One respondent reflected upon the applicability of the method in different contexts, and concluded that how to work, and what tools and methods to use, is directed by the problem at hand. If the problem is in the processes, such as "Students do not get their course credits in time", then process mapping could be a suitable tool, in addition to the others.

The respondents favoured different tools and methods the best. One respondent liked the business model canvas, and thought that it was quite interesting to see that it was applicable in this kind of work. The canvas summarises the whole case, because there is so much previous work that is leading to this analysis. Another respondent favoured the SWOT analysis, because it is easy to use and clear in its instructions. This was also the tool the respondent was familiar with. To think in business modelling terms, for instance "Who are our stakeholders?", was the third respondent's reply. The SWOT analysis and stakeholder analysis really visualises the complexity from a business modelling perspective. The business model canvas could be hard to use for persons not familiar with the tool, according to this respondent. This highlights one of the drawbacks with the method; for people without previous experiences in the business modelling area, there is a learning curve. You need to know how to interpret specific methods and tools, and how to use them efficiently. In this project, an outside project manager was appointed and acted as facilitator. A facilitator helps in directing the whole process one respondent explained, i.e. to not focus on the tools or methods and getting stuck, but to focus on the outcomes. One main benefit was that the project manager came from another department, and had a slightly different background. This brought other perspectives and interdisciplinarity into the project and the department.

The process requires some preparatory work, and it is not a one-man work; you have to cooperate. In particular, you need to involve everyone that should do the actual changes. Unfortunately, as one respondent pointed out, you seldom have the possibility to run these kinds of projects because lack of resources. Basic prerequisites for this kind of work is financing, time and long-term planning. A drawback in this project was that the programmes already existed. It is harder to make changes in existing structures. The method is from that point of view better suited for projects aiming at developing new education programmes.

The respondents also reflected on their own personal learning. "This was the first project I participated in where these kinds of tools and methods were used, and where everything were connected to each other", one respondent said. "Today, I work in similar ways in the current project I am involved in. My 'model thinking' has become better, and the ability to work in a structured way". According to another respondent, the main contribution was the project management approach, including all tools and methods. "It has affected my way to work as project manager", the respondent concluded. Even if the

respondents felt like they learned a lot in the project, the documentation and the formal handover, that is the formalised learning on department level, was seen as problematic. "It is hard to summarise all data in a convenient way and communicate to the teachers", one respondent mentioned. "The results are still of general interest. Many new teachers joined the department, and they might not have the holistic view on the education. The results could be a good way to give them more insights". Another respondent said: "I would like to have a more visible impact in the program. There are so many good things to highlight, and this would be beneficial for the ones working with the programme and for the students to be informed about".

6. Conclusions

The aim of this paper was to promote an innovative approach to education development projects by the application of business modelling tools and methods. A model was proposed and illustrated by a case study conducted on a bachelor of engineering programme at Linnaeus University. Utilising business modelling tools for development projects gives several benefits according to the post-project evaluation. One benefit is *structured decision making* by applying a step-by-step approach for the development project. This is enabled by adapting well-known tools and methods from industry to the educational context, such as in Asif and Raouf (2013), and the complexity of the context could be captured and visualised relatively easy by utilising methods such as SWOT. Another benefit is *knowledge-informed decision making*; the methods require good understanding of the current situation as well as possible strategies to be applied, that is data gathering is necessary before decision making. Shore and Wright (2015) as well as Yingqiang and Yongjian (2016) criticised current quality assurance approaches for higher education as being too rational and instrumental. Collaborative evaluation closes the gap between power and responsibility, thus moving away from an audit culture where metrics and ranking becomes a self-interest, rather than a means for quality assurance. Including *different stakeholder's perspectives* is also valuable in a development project in order to gain a holistic understanding and avoid sub optimisation. The post-project evaluation highlighted the possibilities of cooperation between internal as well as external stakeholders as positive. This is in accordance with findings of for instance Keogh *et al.* (2010), Ryan (2015) and Yingqiang and Yongjian (2016); external stakeholders, as well as internal in the form of teachers and students, should be actively involved in the process. Students are, as Ryan (2015) points out, "at the center of the higher education", and involving them could thus improve the process, while Yingqiang and Yongjian (2016) view stakeholder involvement as a means to rebuilding trust between academy and the surrounding society.

Continuingly, there are possibilities to *adapt* the INT-EXT method for specific contexts. In the example provided in this paper the questionnaires were for instance based on the CDIO syllabus, but applying national syllabuses or requirements would be possible as well. A main drawback with the approach is the resource consumption, especially in the form of time. Structured data gathering takes time to plan and execute. It also requires time for preparation and learning the different tools and methods. Insufficient resources, including time, is a major barrier for change in educational organisations (Akins *et al.*, 2019). Using a dedicated facilitator, leading the process, is therefore suggested. In addition, time has to be allocated for documentation and communication, and naturally also for intervention. Nevertheless, it is our belief that the added value in the form of deeper understanding of both the current situation and suitable directions for development outweighs the drawbacks. The method has good potential to build up true faculty ownership of the changes to be implemented, which is a seen as a critical success factor (Elizondo-Montemayor *et al.*, 2008).

The process results in large amount of information, and for the efficient utilisation of these, a communication plan would be required. Several stakeholders would benefit from being informed of the results in different ways. In the post-project evaluation, teachers and students were mentioned, but the results could also be used within marketing and for discussing educational development with external stakeholders such as industry representatives.

References

ABET (2017), "Criteria for accrediting engineering programs", available at: http://www.abet.org/wp-content/uploads/2018/02/E001-18-19-EAC-Criteria-11-29-17.pdf (accessed 17 May 2018).

Akins, E.E. II, Giddens, E., Glassmeyer, D., Gruss, A., KalamasHedden, M., Slinger-Friedman, V. and Weand, M. (2019), "Sustainability education and organizational change: a critical case study of barriers and change drivers at a higher education institution", *Sustainability*, Vol. 11, p. 501.

Armstrong, P., Bankel, J., Gunnarsson, S., Keesee, J. and Oosthuizen, P. (2006), "A CDIO-based comparison of engineering curricula in the USA, Canada, Sweden and the UK", *2nd International CDIO Conference*, June13-14, 2006, Linköping University.

Asif, M. and Raouf, A. (2013), "Setting the course for quality assurance in higher education", *Quality and Quantity*, Vol. 47, pp. 2009-2024.

Beecroft, R.C. and Schmidt, J. (2014), "Method-based higher education in sustainability: the potential of the scenario method", *Sustainability*, Vol. 6 No. 6, pp. 3357-3373.

Bishop, N. and Mabry, H. (2016), "Using qualitative data to identify student learning barriers and alleviate instructor burnout in an online information literacy course", *Internet Reference Services Quarterly*, Vol. 21 Nos 3-4, pp. 63-80.

Castles, R., Lohani, V.K. and Kachroo, P. (2009), "Utilizing hands-on learning to facilitate progression through Bloom's taxonomy within the first semester", *39th ASEE/IEEE Frontiers in Education Conference W1F-1*, October 18 - 21, 2009, San Antonio, TX.

CDIO (2020), "About CDIO", available at: http://cdio.org/about (accessed 7 December 2020).

Christie, B.A., Miller, K.K., Cooke, R. and White, J.G. (2015), "Environmental sustainability in higher education: what do academics think?", *Environmental Education Research*, Vol. 21 No. 5, pp. 655-686.

Chung, C. (2011), "Changing engineering curriculum in the globalizing world", *New Horizons in Education*, Vol. 59 No. 3, pp. 59-70.

Crawley, E.F., Malmqvist, J., Lucas, W.A. and Brodeur, D.R. (2011), "The CDIO syllabus v2.0 an updated statement of goals for engineering education", *7th International CDIO Conference*, June 20-23, 2011, Technical University of Denmark, Copenhagen.

Cropley, D.H. (2015), "Promoting creativity and innovation in engineering education", *Psychology of Aestethics, Creativity and the Arts*, Vol. 9 No. 2, pp. 161-171.

De Hei, M.S.A., Strijbos, J.-W., Sjoer, E. and Admiraal, W. (2015), "Collaborative learning in higher education: lecturers' practices and beliefs", *Research Papers in Education*, Vol. 30 No. 2, pp. 232-247.

De Langen, F. (2018), "Sustainability of open education through collaboration", *International Review of Research in Open and Distributed Learning*, Vol. 19 No. 5, pp. 96-111.

Elizondo-Montemayor, L., Hernández-Escobar, C., Ayala-Aguirre, F. and Medina Aguilar, G. (2008), "Building a sense of ownership to facilitate change: the new curriculum", *International Journal of Leadership in Education*, Vol. 11 No. 1, pp. 83-102.

Engineers Canada (2017), "2017 accreditation criteria and procedures", available at: https://engineerscanada.ca/accreditation/accreditation-resources (accessed 17 May 2018).

Fonseca, S.C., Pinheiro, R., Barbosa, C., Araújo, A., Vaz-Velho, M. and Alves, R. (2015), "Food innovation and entrepreneurship in higher education: a case study", *International Journal of Food Studies*, Vol. 4 No. 2, pp. 141-147.

Gaus, O., Raith, M., Davey, T., Hannon, P. and Penaluna, A. (2016), "Commercial transfer – a business model innovation for the entrepreneurial university", *Industry and Higher Education*, Vol. 30 No. 3, pp. 183-201.

Gavin, K.G. (2010), "Design of the curriculum for a second-cycle course in civil engineering in the context of the Bologna framework", *European Journal of Engineering Education*, Vol. 35 No. 2, pp. 175-185.

Hargis, J., Cavanaugh, C., Kamali, T. and Soto, M. (2014), "A federal higher education iPad mobile learning initiative: triangulation of data to determine early effectiveness", *Innovative Higher Education*, Vol. 39 No. 1, pp. 45-57.

Illeris, K. (2004), "Towards a contemporary and comprehensive theory of learning", *International Journal of Lifelong Education*, Vol. 22 No. 4, pp. 396-406.

Johnson, R.B., Onwuegbuzie, A.J. and Turner, L.A. (2007), "Towards a definition of mixed methods research", *Journal of Mixed Methods Research*, Vol. 1, pp. 112-133.

Jonsdottir, S., Hughes, R., Thorsdottir, I. and Yngve, A. (2011), "Consensus on the competencies required for public health nutrition workforce development in Europe – the JobNut project", *Public Health Nutrition*, Vol. 14 No. 8, pp. 1439-1449.

Keogh, J.J., Fourie, W.J., Watson, S. and Gay, H. (2010), "Involving the stakeholders in the curriculum process: a recipe for success?", *Nurse Education Today*, Vol. 30 No. 1, pp. 37-43.

Kettunen, J. (2015), "Stakeholder relationships in higher education", *Tertiary Education and Management*, Vol. 21 No. 1, pp. 56-65.

Kim, J. (2015), "Competency-based curriculum: an effective approach to digital curation education", *Journal of Education for Library and Information Science*, Vol. 56 No. 4, pp. 283-297.

Kjaer, N., Vedsted, M. and Høpner, J. (2017), "A new comprehensive model for continuous professional development", *European Journal of General Practice*, Vol. 23 No. 1, pp. 20-26.

Kotler, P., Armstrong, G., Harris, L. and Piercy, N. (2017), *Principles of Marketing*, 7th European ed., Pearson, Harlow.

McDonald, A.S. and Scott, B.F. (1994), *Creating an Integrated Learning Environment. Experiences in Product Design Engineering Education*, IEE Colloquium on Design Education – Bridging the Gap Between Industrial and Engineering Design, May 10, 1994, London, pp. 6/1-6/4.

McLaren, H.J. and Kenny, P.L. (2015), "Motivating change from lecture-tutorial modes to less traditional forms of teaching", *Australian Universities Review*, Vol. 57 No. 1, pp. 26-33.

Mirriahi, N., Alonzo, D., McIntyre, S., Kligyte, G. and Fox, B. (2015), "Blended learning innovations: leadership and change in one Australian institution", *International Journal of Education and Development Using Information and Communication Technology*, Vol. 11 No. 1, pp. 4-16.

Murray, L., McCallum, C. and Petrosino, C. (2014), "Flipping the classroom experience: a comparison of online learning to traditional lecture", *Journal of Physical Therapy Education*, Vol. 28 No. 3, pp. 35-41.

Osterwalder, A. and Pigneu, Y. (2010), *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*, John Wiley, Hoboken.

Patel, F. and Lynch, H. (2013), "Glocalization as an alternative to internationalization in higher education: embedding positive glocal learning perspectives", *International Journal of Teaching and Learning in Higher Education*, Vol. 25 No. 2, pp. 223-230.

Ramsden, P. (2003), *Learning to Teach in Higher Education 2nd ed*, RoutledgeFalmer, New York.

Roberts, P. (2015), "Higher curriculum orientations and the implications for institutional curriculum change", *Teaching in Higher Education*, Vol. 20 No. 5, pp. 542-555.

Roffe, I. (2010), "Sustainability of curriculum development for enterprise education", *Education Training*, Vol. 52 No. 2, pp. 140-164.

Ryan, P. (2015), "Quality assurance in higher education: a review of literature", *Higher Learning Research Communications*, Vol. 5 No. 4, pp. 1-12.

Rytkönen, E. (2015), "University campuses in spatial transformation", *Facilities*, Vol. 33 Nos 13/14, pp. 794-818.

Sad, S., Goktas, O. and Bayrak, I. (2014), "A comparison of student views on web-based and face-to-face higher education", *Turkish Online Journal of Distance Education*, Vol. 15 No. 2, pp. 209-226.

Schmitt Figueiro, P. and Raufflet, E. (2015), "Sustainability in higher education: a systematic review with focus on management education", *Journal of Cleaner Production*, Vol. 106, pp. 22-33.

Shore, C. and Wright, S. (2015), "Governing by numbers: audit culture, rankings and the new world order", *Social Anthropology*, Vol. 23, pp. 22-28.

Simms, C. and Chapleo, C. (2010), "Stakeholder analysis in higher education: a case study of the University of Portsmouth", *Perspectives: Policy and Practice in Higher Education*, Vol. 14 No. 1, pp. 12-20.

Swedish National Agency for Higher Education (1993), "Högskoleförordningen [Higher educational regulation]", available at: https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/hogskoleforordning-1993100_sfs-1993-100 (accessed 29 April 2020).

van Aken, J., Berends, H. and van der Bij, H. (2012), *Problem Solving in Organizations: A Methodological Handbook for Business and Management Students*, 2nd ed., Cambridge University Press, Cambridge.

Wamboyle, E., Adekola, A. and Sergi, B.S. (2015), "Internationalisation of the campus and curriculum: evidence from the US institutions of higher education", *Journal of Higher Education Policy and Management*, Vol. 37 No. 4, pp. 385-399.

Yingqiang, Z. and Yongjian, S. (2016), "Quality assurance in higher education: reflection, criticism, and change", *Chinese Education and Society*, Vol. 49 Nos 1-2, pp. 7-19.

Yorke, M. and Knight, P. (2007), "Evidence-informed pedagogy and the enhancement of student employability", *Teaching in Higher Education*, Vol. 12 No. 2, pp. 157-171.

Corresponding author
Mirka Kans can be contacted at: mirka.kans@lnu.se