WHAT SHOULD WE TEACH?
A STUDY OF STAKEHOLDERS' PRECEPTIONS ON CURRICULUM CONTENT

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ABSTRACT

The Bachelor of Engineering is a complex form of education; it has to meet the requirements of higher education in terms of academic stringency and scientific approaches, and at the same time fulfil the requirements of the companies and other takers on employability and professionalism. The aim of the CDIO initiative is to help educational institutions to fulfil the latter without losing the academic basis. Several studies have been made asking different actors to give their view on education and needed competencies, but these are often delimited to one or a couple of actors. One possible reason is the complexity of conducting such studies. This paper reports on a survey including program students, alumni and industry representatives and covers their perceptions of what is important to include in a Bachelor of Engineering program, and what is not. The methodological issues and choices as well as the main results are accounted for. The program in focus is a three-year Bachelor of Engineering in Forest and Wood Engineering taught at Linnaeus University, and the questions regarding content were based on the CDIO syllabus.

Results show that there are some contents all three groups of actors regard as important; all found knowledge in forestry, material sciences and technology related to wood industry as important. Also, analytic and communication skills, and the ability to work in groups were seen as important. Understanding social and environmental conditions and enterprise and business terms was also necessary. Least important was the ability to communicate in foreign languages and knowledge regarding construction technology and deepened knowledge of forestry.

KEYWORDS

Educational content, CDIO syllabus, mixed study research, stakeholder demands, actors perception, Standards: 2, 11

INTRODUCTION

How can we prepare our students for the first work? Is it possible to combine academic stringency with practical understanding? How do we give opportunities for students to experience that the ideal theories described in books differs from the reality and give them possibilities to practice real problem solving for instance in a situation where insufficient information is provided? How can we train the students in critical thinking? These questions teachers and academics in various technological and engineering subjects struggle with: see for instance Huang et al. (2008), Ferlin et al. (2005) and Jakobsen and Bucciarelli (2007). Knowledge and skills connected to the future area of work are important for reaching high employability of students, but not enough. In addition, the future engineer should also possess abilities and skills such as independence, time management, analytic stringency, critical and reflective thinking, team working capabilities and problem solving skills, Yorke and Knight (2007) and CDIO (http://www.cdio.org/se/index.html). Continuing, understanding for research activities and the ability to apply a scientific approach as well as the ability to discuss and argue for ones solutions and standpoints is required.

The learning environment must, according Illeris (2004), be considered both from its context and from a social perspective, that is, the expectations on the results achieved for learning. The curriculum design affects in other words both those who actively participate in the learning situation and those who benefit from it from a social perspective. All these actors, together with actors that regulate and support learning (such as administrators at a university) are the education stakeholders, Kettunen (2015). Especially teachers and other academic staff who have direct influence in the education define training content and format, Roberts (2015). Understanding different stakeholders and their demands on education and curriculum content is an important input for curriculum decisions. This paper addresses the curriculum content from the viewpoint of students, alumni and industrial representatives. By using the CDIO syllabus as a basis, a common set of question is developed that could be used for all types of stakeholders in different setups. In this paper, three different data gathering techniques are use: a traditional paper-based questionnaire, a web-based questionnaire, and focus group discussions.

DIFFERENT STAKEHOLDERS AND THEIR DEMANDS ON HIGHER EDUCATION

Any business, whether a company selling goods or an institution providing education, has several actors with direct or indirect interest in the business. These actors are called stakeholders, and stakeholders are either affected by the business or influence the business. General business-oriented stakeholder models typically include stakeholders such as employees, customers, competitors, suppliers, owners, creditors and authorities. In the educational context, the stakeholders are slightly different. We identify six main stakeholder groups: competitors, partners, takers, customers, employees and authorities. Competitors are primarily other educational bodies, but these can also be partners. A single institution could even be both a competitor and partner.

An important stakeholder group is the takers, that is, someone who takes advantage of students undergoing training. For an engineering education the future employers could be seen as direct takers, but in a larger perspective also the government could be seen as such. The takers put demand on employability, which is a mix of disciplinary knowledge, personal and interpersonal skills and the ability to transfer knowledge and skills from one disciplinary area to another, Yorke and Night (2007). According to a survey of competence requirements in Swedish industry, the most important competences, apart from basic skills in reading, writing and mathematics, are social and intercultural competence, analytical competence, and entrepreneurial and leadership competence, Schwieler (2007). The alumni, i.e. students who finished their education, form a subgroup of takers. Alumni form a bridge between education and working life and could give insights on the usefulness of educational contents, contribute with industry relevance in the education and help students with the introduction to the working life, and even for fundraising purposes, Ebert et al (2015).

The traditional customer concept is also a bit difficult to apply in higher education. In this case we see the student as the direct customer. There are also a possible future customers; the potential students. In a recent study of Swedish high school students' future decisions, 66% of the students were interested in higher studies, whereof 24% could consider a degree within engineering or technology, Teknikföretagen (2015). Among the group of employees we include those that are directly affected by education, mainly teachers and administrators, but also indirect ones such as communicators. The employees are often the active part in deciding on curriculum content and in curriculum design. According to Roberts (2015) graduate employability, teaching-research relationships, changed understanding of teaching and learning as well as new technologies and flexible delivery options are drivers for curriculum change. The authorities include both local and national governing bodies. In Sweden, the Swedish National Agency for Higher Education determines the goals of general degrees, such as Bachelor of Science and Bachelor of Engineering, Swedish national Agency for Higher Education (1992). The agency also conducts quality assurance and legal supervision of higher education. On European level, the Bologna framework, aiming at creating a comparable system of academic standards, has been a trigger for curriculum design, Gavin (2010).

A SURVEY OF DIFFERENT STAKEHOLDERS' PERCEPTION ON EDUCATIONAL CONTENT

The department of Forestry and Wood Technology at Linnaeus University offers courses and programs that cover the entire value chain from forest to finished wood-based product, and the material wood is a common theme in the education. Currently, the department gives two undergraduate programs (a bachelor's program and a bachelor of engineering program) and one on advanced level (master's program). Moreover, courses in sustainable small-scale forestry equivalent to more than 90 credits are offered. The bachelor's program and the sustainable small-scaled forestry are given only in distance form, while the bachelor of engineering program and the master are offered both as a campus and distance option. The application rate of the bachelor program and to courses in sustainable small-scale forestry is high, while the engineering program and the master program are having trouble in recruiting.

A year-long project funded by the Kamprad Foundation started in 2015 to review these programs with a special focus on entrepreneurship. As a part of this project, surveys of stakeholder expectations and demands were made in spring 2015, with a focus on the engineering program. A stakeholder map for the engineering program was developed for capturing the most important stakeholders, see Figure 1. Interviews, questionnaire surveys and focus group discussions regarding different aspects of the engineering program were thereafter conducted with representatives from industry, potential and current students, teachers and educational administrators. The results were used as a basis for program design enhancements. In this paper, the results from a sub-part of the full study are described. The purpose of this sub-study was to map stakeholders' views on educational content, including current students, alumni and other industrial representatives.

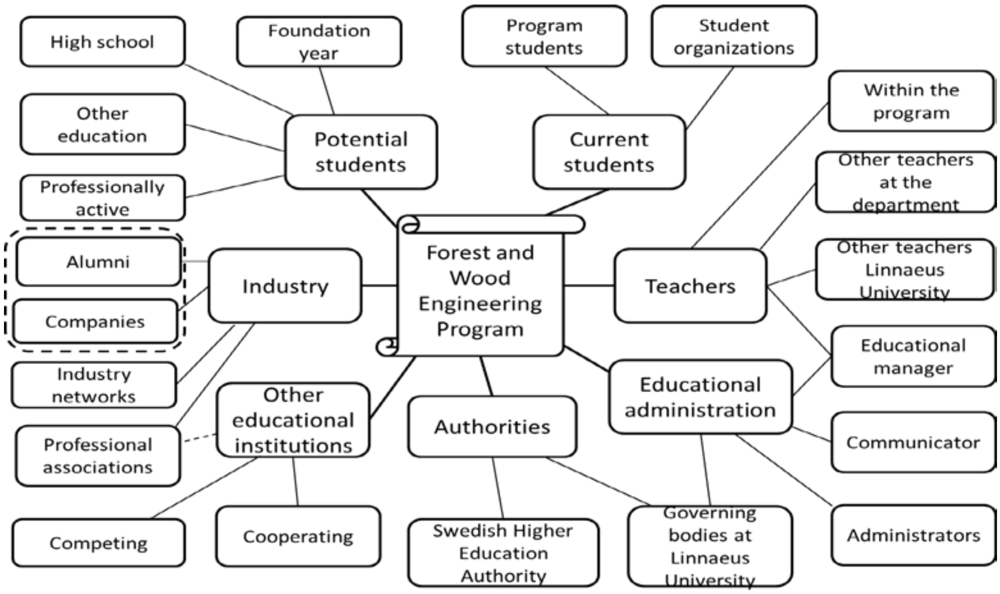

Figure 1. Stakeholder map for the engineering program

Study description

The main data gathering was conducted using a questionnaire survey including 29 questions, whereof two were free text and the rest four-point Likert scale questions. The Likert scale questions were divided into three subgroups (Knowledge, Skills, and Professional and societal understanding). The questions were developed using the CDIO syllabus as a basis. The questionnaire includes all skills and competence groups on the second level of the CDIO syllabus, see Table 1. The personal and professional skills and interpersonal skills were combined in the questionnaire under subgroup “Skills”. The current program syllabus for the engineering program was used for formulating the questions included under the “Knowledge” subgroup, see Table 2. The questionnaire is found in Appendix 1.

Table 1. The CDIO syllabus v. 2.0 at the second level of detail (Crawley et al., 2011)

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 4.4 Designing 4.5 Implementing 4.6 Operating 4.7 Leading engineering endeavors 4.8 Engineering entrepreneurship

The questionnaires were mainly distributed in paper form for the alumni and in web-based form for the current students, see description below. In addition, a focus group discussion regarding educational contents was held with industry representatives together with representatives from academia. The results from this discussion are used as additional input in this study, and for giving depth and better understanding to some of the aspects. Mixing qualitative and quantitative data in this way can add insights and understanding that might be missed when only a single method is used, Johnson and Onwuegbuzie (2004).

Table 2. Bachelor of Engineering in Forest and Wood Engineering syllabus

Area	Courses
Mathematics and science	Basic Mathematics for engineers, Calculus for engineers, Linear algebra for engineers, Mechanics, Applied statistics (optional)
Technology, people, society	Engineering Economics, Quality management (optional), Industrial organisation (optional), Environmental technology and sustainable development (optional)
Other engineering sciences	Computer Aided Engineering, Thermodynamics, Fluid Mechanics and Heat Transfer (optional)
Forestry	Forestry basic course, Forest yield and wood utility (optional)
Forestry planning	Forest Management Planning (optional), GIS in forestry (optional)
Forest fuel knowledge	Forest Fuel Science
Material science	Forest products, Wood as an Engineering Material
Wood-related industrial engineering	Machinery in wood processing, Wood manufacturing
Wood-related industrial manufacturing	Manufacturing in the wood industry
Construction engineering	Building Technology (optional), Structural Mechanics (optional)
Wood-related business administration	Business Logistics, Forest Industry Markets
Other	Methodology course forestry and wood technology, Trainee on Company Placement, Degree project

Data gathering

A web-based survey was sent out to all who were enrolled in the program in the spring of 2015, a total of 38 students. The distribution form was email with a link to the actual survey. Reminding emails were sent twice to those who had not completed the survey. 15 students responded to the survey, representing a response rate of 39%.11 of these were men and three were women, while one respondent chose not to submit gender. The median age of the respondents was 22.5 years. Minimum and maximum age was 20 and 45 respectively. Four of the respondents studied in their first year, seven in year two and four were on their third year. The paper-based questionnaire for alumni was sent by mail to the respondents. A letter was sent approximately two weeks after the original survey was sent in which the respondent was reminded to complete the survey either on paper or via an anonymous web-based survey (link attached in the letter along with a unique code). A total of 148 questionnaires were sent out and of these 22 were answered through the paper version and six via the web. This gives a response rate of 19%. Of the respondents six were women and 22 men. The median age of the alumni respondents was 35.5 years. Minimum and maximum age was 26 and 70 respectively.

A focus group discussion was held on April 14 during a reference group meeting where representatives of academia and industry join to discuss education related issues. Reference group meetings normally take place once per semester. The activity was introduced via presentation material, and the discussion was led by the project manager (the author of this paper), which also took notes and compiled the material. Participants were first asked to note their preferences regarding the 27 questions on a separate form which was distributed at the meeting, and then a discussion in the group followed. Unlike the questionnaires, where a four-point Likert scale was used, the question was formulated more openly as "please note the competence or competencies you find most important, and thereafter note which, according to you, that are least important". The individual responses were collected after the meeting and compiled together with the notes of the discussion. A total of six representatives from the industry were present during the meeting.

MAIN FINDINGS

The main findings from the questionnaire survey and the focus group discussion are presented for each subgroup and thereafter a summarizing discussion of the findings is held. Due to the small data sample, and the use of the Likert scale, mean values are used for ranking. The results are presented using stacked column graphs, where each column represents the total number of answers for the question expressed in percentages. The values range from 1 representing low importance to 4, representing high importance.

Knowledge

The current students' view on the knowledge content is found in Figure 2 a). The students found knowledge about forestry and forestry planning as most important (median = 4). Material science was also seen as important (median = 3,5). The students found other engineering sciences and knowledge in construction engineering, i.e. knowledge outside their own discipline, as least important (median = 2). All knowledge types were ranked fairly high; except for forestry and forestry planning, material science and other engineering sciences and construction engineering, the median value was 3. Alumni ranked the knowledge content a bit differently. Highest median value (4) was found for forestry, material science, technology, people, society, as well as for wood-related industrial engineering and manufacturing. The alumni scored higher median values in general than the current students; between 3 and 4. To point out any particular area that was of less importance is therefore hard. From Figure 2 b) we can distinguish a tendency for lower scores for other engineering sciences and construction engineering, i.e. same as for the current students. Also, the forest fuel knowledge is rated slightly lower.

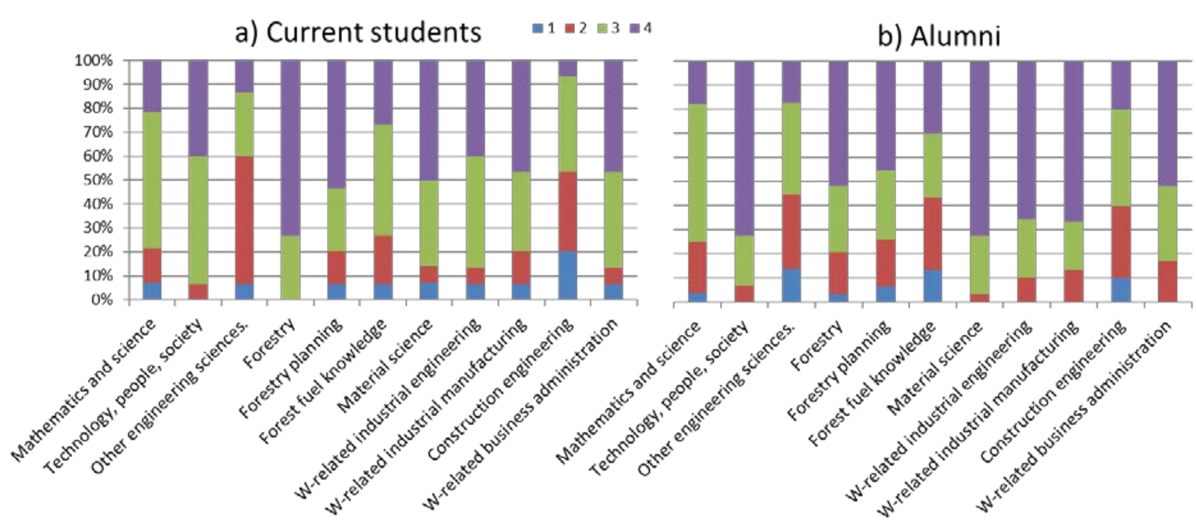

Figure 2. Results subgroup Knowledge for a) current students b) alumni

The industry representatives found knowledge in mathematics and science, technical expertise, and understanding of forestry and wood as material as most important. Engineering know-how is based on the understanding and use of mathematics and the technical expertise is important because it forms the basis for an engineer. Discipline knowledge and general engineering knowledge forms the bases for the future engineer. In addition, understanding of forestry and wood as material is a prerequisite for wood-related product development and production planning. The least important knowledge was, according to the focus group discussion, pure forestry related courses and courses in construction engineering. While there was a consensus that basic understanding of forestry is required, the curriculum should not contain too much of forestry and forestry related courses, because that would change the focus from the whole value chain to the early phases of the value chain. Full consensus whether construction engineering was important or not did not exist though; some argued that the knowledge was important because a big application area for wood products is within construction. Others saw construction as too far from the program scope.

Skills

Personal, professional and interpersonal skills were ranked high both by current students and alumni, see Figure 3. Also here the alumni scored higher in total median compared to the students. In the student responses three out of eight skills scored 4, while the rest scored a median of 3. The skills with median of 4 were analytical thinking and problem solving, teamwork and communication. Alumni scored a median of 4 for six out of eight skills; only ethics, equity and responsibilities, and communication in foreign languages had a median of 3.

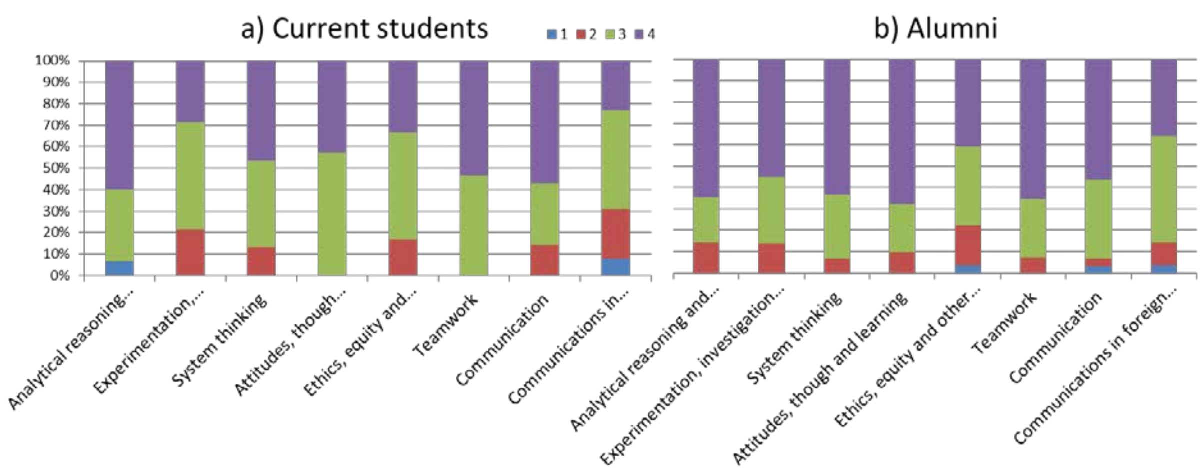

Figure 3. Results subgroup Skills for a) current students b) alumni

The industry representatives found analytic thinking and problem solving as well as experimentation, investigation and knowledge discovery important. These skills are strongly connected to the basic engineering know-how. Other important skills are the ability to work in groups and communication skills. Inability to communicate means that you cannot convey ideas and the engineering expertise is not realized. Ethics, attitudes and other responsibilities were also seen as important: “As an engineer, I lay the foundation for future products, and therefore these skills are important.” Least important was the ability to communicate in foreign languages, according to the focus group. Even if the corporate language often is English today, it is hard to train the language capabilities to reach a high enough level within a three year program. The most important is the ability to discuss and converse with others, but this ability did not have to be an obligatory part of the curriculum, some representatives reasoned. The group also disagreed about the team work abilities; while many saw this as an important skill, others saw the engineer mainly as a leader, and not as a team worker, thus not necessarily needing team working abilities. The focus group suggested adding leadership abilities and several skills connected to attitudes, though and learning. The latter indicates that this skills' group was seen as important even if it was not specifically mentioned in the discussion.

Professional and societal understanding

The current students pointed out only one area of higher importance in this subgroup: entrepreneurship (median = 4). The rest of the skills areas scored a median of 3. Notable in Figure 4 a) is the relative weight put on implementing systems. In Figure 4 b), accounting for alumni results, understanding how to operate systems is in focus. Understanding of enterprise and business contexts was scored highest amongst alumni (median = 3,5).

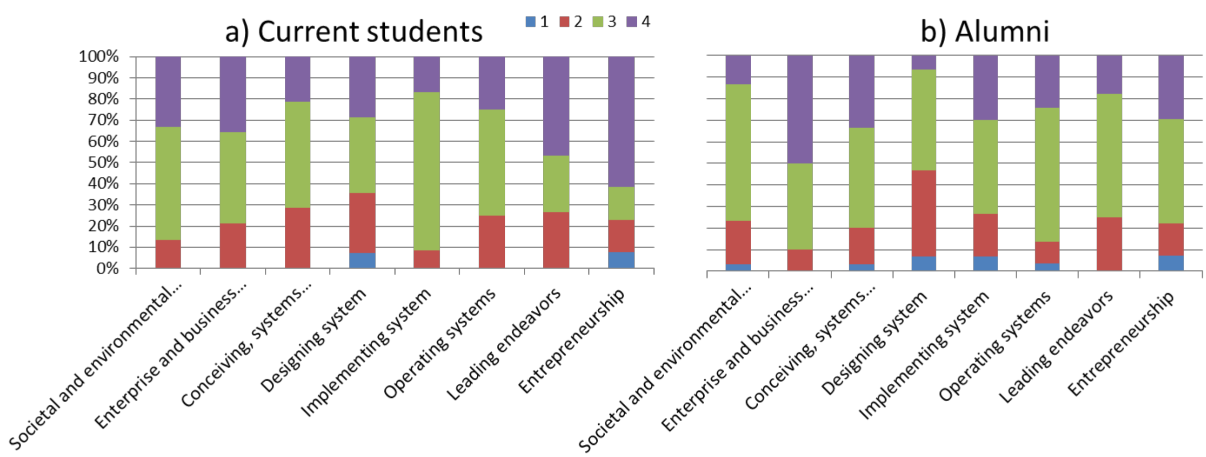

Figure 4. Results subgroup Professional and societal understanding for a) current students b) alumni

In the focus group understanding of enterprise and business context as well as entrepreneurship were seen as important. A fairly long discussion regarding entrepreneurship was held, because some representatives saw this as least important. An argument in favor for entrepreneurship was that "An engineer must be able to see new ideas and realize them", while others saw the engineer as not being an entrepreneur. It was also discussed whether an entrepreneur would enroll in higher education at all – many famous entrepreneurs are self-learned. The importance of entrepreneurship depends on where you fall in employment. A larger company has in-house training and their own way of working with innovation, while in a small business, innovation skills could be extremely important. The group agreed upon that all students would benefit of a certain understanding of entrepreneurship, and that the ability to lead innovations is more important for an engineer.

Results discussion

The stakeholders have in common that they believe that material science and understanding forestry, i.e. the conditions in which the material is produced, are important. Participants from industry emphasizes the general engineering knowledge, such as mathematics and technical expertise, while alumni focus on the later phases of the value chain (wood-related industrial engineering and manufacturing). Alumni also rank knowledge in technology, people and society, i.e. courses offered to all engineering students that give insights in the economical, business related, societal and environmental aspects of engineering. Least important was deepened knowledge in forestry and in construction engineering. These courses are today optional (except for the course in forest fuel science), so from the knowledge perspective, the current curriculum seems to be well fit to student expectations as well as future takers' needs. Suggestions from the industry representatives of more wood industrial courses and to add product development to the curriculum were given. The stakeholders agree that analytical thinking and problem solving, teamwork and communication are important skills, even if there was a slight disagreement within the focus group regarding teamwork. Communication in foreign languages was seen as less important, while there were different viewpoints on the ethics and equity; the alumni ranked this skill low while industry representatives saw this as important. The importance in understanding enterprise and business contexts was common for all stakeholders. The students ranked entrepreneurship as important as well, while the industry representatives saw the ability to lead innovations as important. These results were used as input for curriculum change decisions together with several other findings, in which the mapping of the curriculum with respect to the CDIO syllabus was one major input. The mapping pointed out strong areas (connected to CDIO syllabus skills 1.1-1.3, 2.1-2.3, 3.2, 4.1) as well as areas in need of further development (connected to CDIO syllabus skills 2.4-2.5, 3.1, 4.2, and 4.7-4.8). To mention some improvements in the curriculum, a course in leadership was introduced that strengthened the teamwork and leadership training as well as training in ethics and equity, and several activities in entrepreneurial thinking, i.e. in seeing and acting on opportunities, were added to the current courses.

CONCLUSIONS

This paper reports on a study aiming at understanding different stakeholders' preferences with respect to curriculum contents. The data gathering was made using the CDIO syllabus as a basis, and it is concluded that this approach was workable and resulted in useful findings. Thus, it is possible to survey different stakeholder preferences with the same set of questions, even if the actual survey setup and distribution form differs. If possible, the same data gathering technique should be used for all participants, and we find both strengths and weaknesses in the three data gathering techniques used in this study. The focus group discussion gives deepest understanding but it is hard to distinguish individual preferences, while questionnaires give possibilities to compare results within and between stakeholder groups but no explicit explanation to the patterns one find. It is therefore suggested, for best results, that the questionnaire survey is combined with focus group discussions for each stakeholder group included in the survey. This was not possible in the study described in this paper due to time restrictions as well as geographical spread of respondents but future studies would take advantage of for instance program meetings that gather the current program students and the alumni gathering held in December each year.

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BIOGRAPHICAL INFORMATION

Mirka Kans is an associate Professor in Terotechnology at the department of Mechanical Engineering and has been program director for several educational programs since 2004 and forward. She is active in developing the education practices and curriculum according to student centered and active learning concepts (e.g. in form of CDIO), and in close collaboration with industry. Research focus lies within data and information systems for industrial management, and especially on data and IT requirements for maintenance management and how to support maintenance by means of IT to achieve cost-effectiveness.

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APPENDIX 1. QUESTIONS INCLUDED IN THE SURVEY

All questions used a four point Likert scale, such as the example provided below. The respondent has the possibility to not answer the question either by skipping the question or by the option "Do not know".

1 --------------------2--------------------3-------------------- 4   Do not know: ☐

Knowledge:

2.1 Mathematics and science. For example basic algebra , vector geometry , mathematical statistics and physics.

2.2 Technology, people, society. For example quality engineering, environmental engineering, sustainable development, industrial management or organizational learning.

2.3 Other engineering sciences. For example CAD, electrical engineering or control engineering.

2.4 Forestry. For example forest measurement techniques, silviculture and forest economy.

2.5 Forestry planning. For example how to develop a forest management plan, quality issues in the value chain from the forest to the final product , and forestry applications of geographic information systems (GIS).

2.6 Forest fuel knowledge. For example forest-based biofuels in terms of assets, properties and handling.

2.7 Material science. For example the wood structure and properties, and how the properties are expressed in various wood products or wood processing.

2.8 Wood-related industrial engineering and processing technology. For example processing methods for wood or techniques for processing in the wood industry.

2.9 Wood-related industrial manufacturing. Such as production management or production economics.

2.10 Construction engineering. For example civil engineering, building physics, building materials and building mechanics.

2.11 Business administration with specialization in forest and wood industry. For example logistics (handling of materials / information / monetary flows within and between enterprises) or the forest industry markets (market analysis, sales, purchasing, trade and contract).

Skills:

2.12 Analytical reasoning and problem solving. The engineer must be able to simplify complex problems by constructing relevant models and analyze these models to draw quantitative and qualitative conclusions.

2.13 Experimentation, investigation and knowledge discovery. The engineer must be able to make hypotheses about the engineering issues, to demonstrate how these hypotheses experimentally could be tested and be able to draw conclusions from these experiments.

2.14 System thinking. The engineer must be able to view components of a subsystem in an overall perspective and be able to prioritize and compromise in order to optimize the operation of the system as a whole.

2.15 Attitudes, though and learning. The engineer must be able to seek new solutions to technical problems as well as being critically curious about the technological developments in their own discipline, and adjacent areas.

2.16 Ethics, equity and other responsibilities. The engineer must be able to act ethically with integrity within the discipline and exhibit a professional demeanor.

2.17 Teamwork. The engineer must be able to understand and be able to perform in different roles in a project. The engineer should also be able to build effective teams and lead development projects.

2.18 Communication. The engineer must have good written, oral and electronic communication skills as well as have the ability to interpret and communicate messages through diagrams, flow charts, and other graphical methods. The engineer should also be able to analyze a text with respect to the underlying message and be able to develop messages based on its strategic role.

2.19 Communications in foreign languages. The engineer shall easily read, write and speak about the own discipline in the English language. Languages in the European locale or other major language groups are a great asset.

Professional and societal understanding:

2.20 External, societal and environmental context. The engineer must understand and evaluate their own role and impact of technology on individuals, society, environment and external environment and be able to evaluate the technology in a global long -term perspective. The engineer must also have knowledge of the laws governing the operations of their own industry and in activities related to research, technology development and production in general.

2.21 Enterprise and business context. The engineer must understand the implications of the economic basic terms and understand the economic conditions for business activities. He / she must have the ability to make commercial considerations in the process of system development, design and production.

2.22 Conceiving, systems engineering and management. The engineer must be able to analyze technical systems, breaking them down into subsystems, detailing the objectives and requirements of each of these subsystems and define the interfaces between sub-projects. He / she should have knowledge of the use of project models, how to participate in and lead development projects and how to formulate system descriptions and project plans.

2.23 Designing systems. The engineer must have the knowledge that he / she can construct the prototype system within their technical area and have experience in prototype construction in multi- disciplinary environments.

2.24 Implementing systems. The engineer must have knowledge of the adjustments in the design, layout and design must be done when prototypes are developed into products and systems adapted for manufacturing, distribution and sales, and have the ability to implement this adjustment in the context of a project.

2.25 Operating systems. The engineer must have knowledge about methods of quality assurance and ability to lead efforts to maintain and develop the technical systems. He / she should also be able to contribute in the process of analyzing the product or system material and energy impacts in a lifecycle perspective.

2.26 Leading endeavors. Be able to develop and implement visions, ideas or solutions.

2.27 Entrepreneurship. Leadership and organization, business development, networking and financing of new ideas and activities. Marketing and business innovation.