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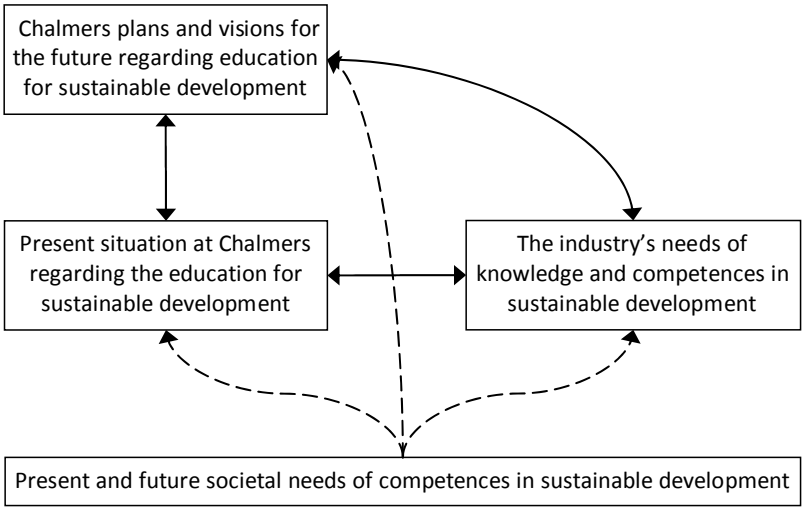

The Swedish industry's needs of competences in sustainable development

A comparative analysis to the engineering education at Chalmers University of Technology

Master of Science Thesis in the Master Degree Program Industrial Ecology

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Department of Energy and Environment
Division of Physical Resource Theory
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2010

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Abstract

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The engineers employed in the Swedish industry develop and work with a multitude of products and processes, which have varying influence on society and the environment. It is thus important for engineers to have a good understanding of how the products and processes they work with affect sustainable development. And, in order for the engineers to receive relevant education in the field of sustainable development, it is important for educational institutions to have an understanding of what competences are needed amongst future engineers.

This report discusses the competences in sustainable development (SD) sought after by the Swedish industry. It also presents a comparison to the engineering education at Chalmers University of Technology (Chalmers) in order to analyze if the education at hand meets the competence needs within the industry.

The report is based on interviews with sustainability managers and other relevant personnel at 16 major companies in Sweden. These companies cover areas such as manufacturing, energy, consultancy, construction, and retail and are based in Sweden but have both national and international presence. It is also based on an analysis of contents in 70 courses on environment and SD at Chalmers. The interviews and course content inventory were compared, an in order to provide further details, the views on SD competence needs amongst Chalmers alumni and students were gathered through two surveys.

The results indicate that the Swedish industry demands a higher general competence level in SD amongst all engineers. The company interviewees mention that all engineers need a better understanding of basic issues regarding SD in order to make relevant choices in their daily work. This is confirmed by the alumni where 35 % claim that they encounter SD issues sometimes or daily in their work, but at the same time only 47 % of the above mentioned alumni claim they have enough competence to make decisions from a SD perspective. The company interviewees and alumni regard competences in environmental issues and sustainable business development as important. The company interviewees also mention communication as an integral part of SD competence. The course content inventory has shown that environmental issues are focused upon the most in the SD education at Chalmers, and business development and social issues are less focused upon.

KEYWORDS: Education for Sustainable Development, engineering education, higher education, competencies, Swedish industry's needs

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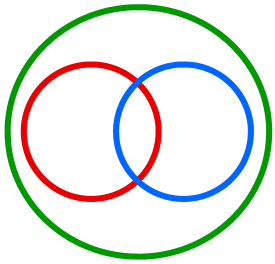
One Ring to rule them all,
One Ring to find them,
One Ring to bring them all
and in the darkness bind them.



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List of abbreviations and expressions

BScEng	Bachelor of Science in Engineering
BTH	Blekinge Institute of Technology
CDIO	Conceive, Design, Implement, Operate
CSR	Corporate Social Responsibility
EMA	Environmental Measurements and Assessments
EESD	Engineering Education for Sustainable Development
ELR	Environmental Literacy Requirement
ESD	Education for Sustainable Development
FOI	the Swedish Defence Research Agency
GWE	Geo and Water engineering
IE	Industrial Ecology
IPCC	Intergovernmental Panel on Climate Change
ISCE	Innovative and sustainable chemical engineering
KTH	Royal Institute of Technology
MSc	Master of Science
MScEng	Master of Science in Engineering
REACH	REACH is the Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals, a legislative framework on chemicals of the European Union (EU)
SD	Sustainable Development
SES	Sustainable Energy Systems
TUDelft	Delft University of Technology
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPC	Universidad Polytechnica de Catalunya

Bachelor of Science in Engineering	A student conducting a three-year engineering program(högskoleingenjör in Swedish).
Education for SD	Referring to the concept of ESD and education which aims at achieving a sustainable development.

Education in environment and SD	Referring to the actual courses in environment and sustainable development available at Chalmers educating students in the concept, relevant methods etcetera.
Master of Science	A student conducting a 2 year Master of Science program.
Master of Science in Engineering	A student conducting a five-year engineering program (civilingenjör in Swedish).

" – We have had a sustainability course for almost all employees /…/ in order for us to get a common awareness platform around the issue."

- A sustainability manager at a manufacturing company [25]

Part 1: INTRODUCTION, GENERAL THEORY AND OVERALL METHODOLOGY

The aim of this part is to give the reader an understanding of the aim and objectives of this master thesis; an overview of the theory surrounding education for sustainable development (ESD) and insight into the present situation at Chalmers regarding ESD. The theory presented gives the reader the background knowledge needed to understand the topic and the surroundings in which the thesis acts.

1 Introduction

Sustainable development (SD) is a constantly growing and developing issue in society today. Chalmers University of Technology (Chalmers) has taken the approach of acknowledging the importance of SD and is implementing its vision of incorporating SD in many areas. Chalmers initiative of becoming a university with an SD approach can be viewed as a way of distinguishing the university from other universities and as an attempt to gain competitive advantage. In order for Chalmers to protect its brand and good reputation, it is therefore important for Chalmers that the education, concerning SD, consists of top of the line courses, based on updated and relevant ideas. These courses should help the students to attain the knowledge and skills needed to meet the competences demanded by the Swedish industries and other potential employers as well as the long-term needs of society.

1.1 General description of the research problem

Since SD is a constantly evolving concept, it is essential for educational bodies to be flexible and make sure that they are regularly updated regarding demand for and supply of knowledge and competences in SD.

Chalmers strive to guarantee, and continuously improve, the quality of the environment and SD education (Chalmers, 2009c). One way to achieve this is to assure an education that benefits the university, industry and society. Thus, there is a need for studying the present and future industry and societal demand for competences in SD.

Chalmers aim for its visions and goals is to be highly influenced by the present and future situations in the industry and society. Additionally, educational goals set by Chalmers should meet present and future demands of the industry, as well as to act as a driver for pushing the industry in a desired direction. In Figure 1, a description of the interdependencies between the needs of the industry, the needs of the society, Chalmers' present educational situation, and Chalmers' desired future educational situation is presented.

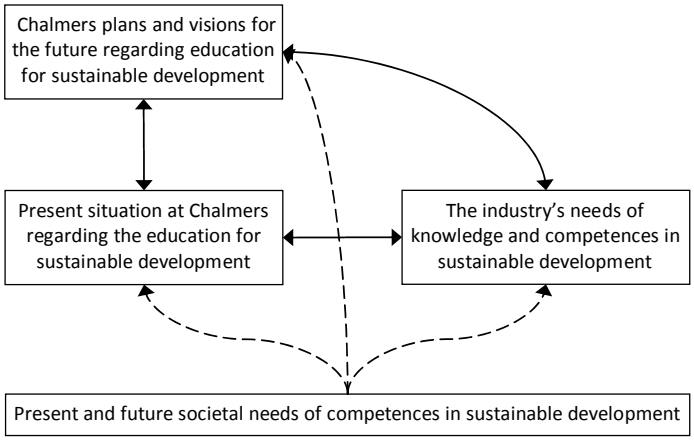


Figure 1: Description of the interdependencies between Chalmers, the industry and society regarding needs of knowledge and competences in sustainable development.

1.2 Objectives

This master thesis examines the Swedish industry's demand for knowledge and competences among engineers within the field of SD, the knowledge and competences supplied by Chalmers within the same field, and a possible gap between the two.

The objectives of the master thesis are:

- to identify what knowledge and competences within SD engineers in the Swedish industry utilize today

- to identify what knowledge and competences within SD engineers in the Swedish industry predict to demand in the future.

It is the authors' intention that Chalmers should be able to use the results as guidance to where the education already corresponds to the present and future needs, and where improvement is needed, so that the bachelor and master education can be adjusted in ways that are appropriate.

1.3 Delimitations

This master thesis only assesses the demand for knowledge and competences within the field of SD on the Swedish scene. It makes comparisons with the knowledge and competences supplied by Chalmers as can be judged by available course content and not by assessment of the students' actual learning. Both international and national corporations were involved and among those, only actors with well developed[1] SD or environmental competences were contacted.

The authors identified four different types of engineers within the field of SD. The first type includes those who take bachelor level courses on environmental studies and SD. The second type consists of students who choose to enhance their SD knowledge in a master's program within the SD field. The last two types are students who do nothing of the above or choose to follow a three- or five-year engineering education entirely devoted to SD. This master thesis only focuses on the first and second type of engineers since the third and fourth type are presently not educated at Chalmers. Thus, all engineering students studying a three-year or a five-year engineering program at Chalmers fall into the scope of the study.

The inventory does not include the educational areas architecture, marine & nautical science, and business development & entrepreneurship for construction & property, since these three areas do not result in a three- or five-year engineering degree.

Most of the collected materials were originally in Swedish, hence translated by the authors.

More specific delimitations will be discussed further in the report related directly to the different parts of the thesis.

1.4 Report outline

The overall methodology chosen in order to achieve the aim and objectives of this thesis was based on three different approaches. Firstly, a course content inventory of Chalmers in SD was performed. Secondly, interviews were conducted with different companies operating in Sweden and a focus group discussion was conducted with people from various organizations. Thirdly, two different internet-based surveys, shaped as questionnaires, were created and sent to Chalmers alumni as well as current students in order to verify the results from the interviews and the inventory.

The report outline is based on six parts, which to some extent also represents the chronological order of the project.

The first part, *INTRODUCTION, GENERAL THEORY AND OVERALL METHODOLOGY*, gives an overall introduction to the research by discussing the research problem and the aim of the report. This part

1 The authors defined well developed performance as the existence of at least a person or a department with main task to perform sustainable development or environmental work.

also includes general background theory related to the research problem and an overview of the methodology.

The second part, *COURSE CONTENT INVENTORY OF CHALMERS EDUCATION FOR SUSTAINABLE DEVELOPMENT*, deals with the course content inventory. The objective of the inventory is to assess Chalmers' courses in SD by determining the type and amount of course contents are present in Chalmers courses in environment and sustainable development. The inventory results were also used as a basis for outlining issues to be discussed in company interviews and survey questions.

The third part, *INTERVIEWS TO UNCOVER INDUSTRY AND SOCIETAL COMPETENCE NEEDS IN SUSTAINABLE DEVELOPMENT*, covers the interviews performed during the thesis work. The interviews were conducted in order to provide information on current competence needs in the Swedish industry. The objective was to describe what engineering competences in SD that companies use today, and what competence needs they expect to have in the future. A focus group discussion that aimed at assessing future societal needs of SD competences was also conducted.

The fourth part, *SURVEYS TO VERIFY INVENTORY & INTERVIEW RESULTS*, is intended to give an additional view on the industry's competence needs and the attained knowledge in SD among engineers. The primary objective is to verify, or disprove the results from the interviews. This is done by addressing a broader sample than the interviews respondents. The secondary objective with the two surveys, one alumni and one student survey, was to assess which important competences the alumni do not experience that they possess, if any, and what knowledge and competences the students believe that they have attained, and relate this to the interview and inventory results.

The fifth part, *DISCUSSION*, concerns the simultaneous interpretation of all results from the previous parts and discusses the quality of the interpretations made.

The sixth and last part, *CONCLUSIONS*, gives the reader the authors' conclusions regarding the research problem and recommendations corresponding to the aim and objectives of this report.

2 Theory

Some aspects of the research problem have previously been examined from other points of view. This chapter accounts for the relevant previous research and clarifies concepts and terminology used.

2.1 Sustainable Development, Sustainability, and Education for Sustainable Development

Precise definitions of Sustainable Development and Education for Sustainable Development (ESD) are not necessary for the reported work, however it is included so as to provide the uninitiated reader with basic understanding of the issue.

SD is often described as the concurrent development of society, economy and environment. This view was commented on by the United Nations' (UN) World Commission on Environment and Development report *Our Common Future*, also called the Brundtland report (World Commission on Environment and Development, 1987):

> *" Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs "*

The Brundtland vision consists of three intersecting issues; social, economic and environmental, and sustainable development is achieved by the integrations of the three systems (Mebratu, 1998). Instead of using the most frequently used conceptualization of SD, which is the three intersecting circles depicted to the left in Figure 2, the authors prefer to view this as economic and social systems intersecting but within the environmental system, believing that the environmental system sets the system boundaries for sustainable development. From a business point of view, due to that companies work as economic institutions, a third version is most suited, where environmental and social issues intersect while the economic issue sets the system boundaries. A fourth version may also exist, where social issues sets the outer boundaries for sustainable development, see Figure 2.

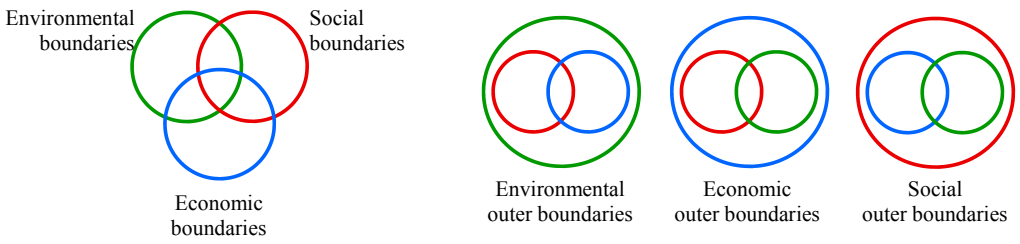


Figure 2: Sustainable development from different views. In the leftmost picture (Brundtland) all three aspects intersect and in the middle a sustainable society can be found. The other three represents the environment (green), the economic (blue) and the social (red) boundaries as the outer and thus most restricting boundary.

Both the phrase sustainable development and the word sustainability are commonly used today. According to Mebratu (1998) the term sustainable development can be used for describing the desired end state, whereas sustainability puts emphasis on the progress towards achieving sustainable development (Mebratu, 1998):

> *"the objectives of sustainable development will /…/ be to maximize goal achievement across these three systems at one and the same time"*

The authors agree with this definition and view sustainability as something industries, societies and people can strive for and achieve, short term and long term, and which will enhance the overall societal progression, towards sustainable development. However, in order to facilitate the reading, the authors will throughout the report use the phrase sustainable development, and the abbreviation SD, as a collective name referring to both the processes of achieving the end state and the end state itself. Nevertheless, whenever the text refers to or quotes others who use the term sustainability instead of SD, the terms are not exchanged.

ESD is a collective name for all education aiming at achieving competences that are seen as important for SD, especially when this knowledge goes beyond or outside the traditional content in different types of education. For Chalmers, this abbreviation is applicable for numerous activities. This report covers competences and knowledge of students and former students in educational programs for Bachelor of Science in engineering (three-year engineering programs, BScEng) and Master of Science in Engineering (five-year engineering programs, MScEng) programs. Within engineering ESD (EESD), there is often an emphasis on environmental issues due to the heavy focus on innovation and application of technical solutions to the environmental system in engineering education.

2.2 Definitions of knowledge and competence

This report distinguishes between the two expressions knowledge and competence. The Oxford English Dictionary defines knowledge as "information acquired by study; learning" and competence as "sufficiency

of qualification; capacity to deal adequately with a subject /…/ adequacy of a work; legitimacy of a logical conclusion" (Oxford English Dictionary, 1989). Competence can also be described as "combinations of knowledge and intellectual skills" (Bloom, 1956). Additionally, the Swedish Standards Institute defines competence as "the ability and will to perform a task through application of knowledge and skills" (Swedish Standards Institute, 2009). These definitions correspond to the authors' view of knowledge being taught at universities whilst competence is required when the engineers are performing their working role. It is also the view of the authors that knowledge can be turned into competence by exercising application of the knowledge to different contexts. What is mostly given at universities is the knowledge needed in order to achieve competence. However, with course contents that can be applied to the real world and real life experience during university studies, an engineer would be able to attain competences while studying.

2.3 Chalmers education for sustainable development today

Chalmers educates two different types of engineers, BScEng (three years) and MScEng (five years). It is mandatory for all Chalmers students who are studying in a three- or five-year engineering program, to pass a course, or to study course contents[2], in environment and SD during their bachelor studies at Chalmers. Additionally, there are five MSc programs with a specific focus on SD.

For this master thesis, it is possible to identify two types of students at Chalmers; the generic engineer, who has at a minimum taken one course, or the corresponding course contents spread out over several courses, in environment and sustainable development, and the student who, in addition to this, has a Master of Science degree in the field of SD. The two types of engineers are the two extremes on a large scale. All three- and five-year engineering students at Chalmers fall into this range, hence the research only focuses on these two extremes. These two types of engineers correspond to engineers of type one and two mentioned in section 1.3.

2.3.1 The structure of Chalmers education in sustainable development

One of the reasons for the education in environment and sustainable development at Chalmers is based on the national legislation governing the different degrees which can be awarded at Chalmers(Chalmers, 2009h). In the Swedish Higher Degree ordinance (2003), the fundamental goal of the education is stated and for a five-year engineering degree, the following applies to SD:

> *"A five-year engineering student shall have the capacity to develop and design products, processes and systems, in regard to human requirements and needs, and for the societal goals of economically, socially and ecologically sustainable development."*

In addition to Chalmers main requirement of taking a course, or course contents, in environment and sustainable development, all students are required to attend a one hour lecture on SD at the beginning of their studies at Chalmers (Chalmers, 2010). There is also a requirement in the rules for master thesis work (Chalmers, 2009f) stating that a student must take SD into consideration in their thesis:

> *"The student is to demonstrate: the capacity to identify the issues that must be addressed within the framework of the specific thesis in order to take into consideration all relevant dimensions of sustainable development."*

[2] The students must attain 7.5 higher educational credits in environment and sustainable development

The organizational responsibility to create and follow up the goals for the education in environment and sustainable development is today vested in the Committee for pedagogy and competence development (Chalmers, 2009g). The regulation governing the committee states:

> *"The committee has a special responsibility to watch over and push forward the development within education for sustainable development."*

The committee also has the responsibility for stating and for following up goals:

> *"The committee shall state and follow up goals within ESD."*

Moreover it is the responsibility of the program directors to make sure that national and local degree ordinances are followed and to incorporate SD into their respective programs. In practice, the examiners and course leaders also have a large responsibility for and influence on the actual course content.

2.3.2 Chalmers goals and visions for the education for sustainable development

Along with the rules and regulations that govern the education today, Chalmers' visions and goals are the backbone in its education for sustainable development. Chalmers' education is governed by different strategy documents, in which Chalmers has put forward several visions related to SD. The most prominent is Chalmers' overall vision, *Chalmers – for a sustainable future* however it does not specifically speak of educational goals (Chalmers, 2008a). In Chalmers' environmental policy, more information related to ESD can be found (Chalmers, 2008b):

> *"The education at Chalmers should give tools and an understanding for how to develop technologies for society in sustainable systems"*

Additionally, a goal stated in Chalmers outlook toward 2015 is to offer work-related training in SD to already graduated engineers (Chalmers, 2009e):

> *"In 2015, the possibilities for working engineers and others to acquire training in sustainable development will be fully developed."*

That an awareness of SD should permeate all educational programs at Chalmers is another goal mentioned in the outlook toward 2015 (Chalmers, 2009e):

> *"In 2015, an awareness of sustainable development permeates all educational programs at Chalmers."*

In order for the students to get a good basic understanding of SD, Chalmers has created a guideline known as the indicative text for learning outcomes (2009h) stating the learning outcomes a student should attain from the mandatory 7.5 credits on environment and SD.

2.4 Previous research on education for sustainable development

Previous research within the field of ESD focuses on learning outcomes in ESD and on how ESD should be implemented in higher education institutions. Research on industry's needs of competences in general has been conducted however little research has been found that is assessing competences in SD that are sought after by the industry.

A study addressing learning outcomes, conducted in the USA, looks into what is known as "Environmental Literacy Requirement" (ELR). A number of universities in the USA have a program intended to raise students' environmental literacy through mandatory courses on the subject (Moody &

Hartel, 2007). This can be compared to Chalmers' own 'environmental and sustainable development literacy requirement', which demands students to take at least one course in environment and SD during their studies at Chalmers (Chalmers, 2009b). The study by Moody & Hartel (2007), shows that the ELR, when implemented, increased the students' knowledge and concern about environmental issues. The study also states that it is ideal to infuse the entire university curriculum with environmental literacy in order to gain the most effective outcome instead of environmental education becoming another 'add-on' to the curriculum (Moody & Hartel, 2007). As a concluding remark, Moody & Hartel (2007) state that an ever-growing number of universities in the USA will be implementing ELRs at their institutions in order to educate students that will be able to tackle upcoming environmental issues.

There has been a series of conferences on EESD, and a paper providing an overview of relevant questions addressed at these conferences states that external stakeholders should be closer connected to university education and that student are motivated by working with real life problems handed out from external stakeholders (Fokkema, Jansen, & Mulder, 2005). Regarding what topics engineers should focus on Fokkema et al. (2005) point out climate change, equity, destruction of ecosystems and resource depletion as some of the most important areas of SD. Regarding how much engineers should know, Fokkema et al. (2005) mention that "knowledge in SD is a basic qualification for engineers" at many universities and that "apart from a basic knowledge on SD for every engineer, there is a need for SD engineering specialists". A closing address of the EESD conference in 2002 stated that (Fokkema, Jansen, & Mulder, 2005):

> *"Each engineer should have an awareness of possible ethical, social, environmental, aesthetic and economic implications of their work and be able to act accordingly"*

Previous research has also been done in the area of defining and assessing learning outcomes, taking the view of the educating institution and their role in ESD. One paper that contains a review of existing sets of learning outcomes for ESD states that it is important for professionals to be skilful in their disciplines; however they still need to have knowledge in systemic thinking and a complex frame of reference when it comes to the matter of SD (Svanström, Lozano-Garcia, & Rowe, 2008).

An attempt to analyze the competence sought after by the industry was made by the Swedish Association of Graduate Engineers (Sveriges Ingenjörer) by sending out a survey to engineering alumni from 2005 and 2006 (Dahlberg, 2009). The survey took a stance out of the national ordinance for higher education, stating what an engineer should know upon completing their degree (Swedish Ministry of Education and Research, 2010). Dahlberg (2009) asked the engineers whether they had acquired enough knowledge during their studies in order to "develop technology for sustainable development". 50 % answered that they had been "poorly" or "very poorly" prepared to do this, or they had "no opinion" on whether they could develop such technologies. This result stood in staunch contrast to other areas such as analyzing and evaluating different technical solutions or working in groups, where more than 80 % said that they were "well" or "very well" prepared to do so.

Another attempt to ascertain whether the engineers of today have enough knowledge in SD was made by Chalmers in the shape of a survey similar to the one made by the Swedish Association of Graduate Engineers (Chalmers, 2009a). The survey used the same approach as Dahlberg (2009) when selecting questions and one question asked the engineers "whether they had attained knowledge in sustainable development during their studies at Chalmers". In this study, on a scale from "very limited" which was marked as 1, to "very good", which was marked as 10, 66 % stated they had attained very limited knowledge, up to 5. Only 7 % answered that they had knowledge close to 9, or 10 (very good), whereas the rest (27 %) answered in the region of 6-8 (Chalmers, 2009a).This, as in Dahlberg (2009), stood in contrast to other areas where most respondents leaned towards a more positive view, and where more than 50 % thought they had attained knowledge corresponding to a 6 or above.

2.5 The industry's work with SD through corporate environmental and social responsibilities

Corporate environmental and social responsibilities have developed in parallel over the years; however they have been, and often are, seen as separate issues. Due to this their historical backgrounds are here described separately. The theory does not discuss future corporate SD work. This delimitation is made due to that this thesis deals with the Swedish industry as a whole, and not specific businesses, and relevant theory on future corporate SD work were therefore not found.

2.5.1 Historical development of the industry's work with environmental responsibilities

Large industrial incidents, related to e.g. contamination of soils, oil spills and hazardous waste dumping, and the release of Rachel Carson's book 'Silent Spring' and the Brundtland report, has triggered public awareness over the last decades and companies' acknowledgement of environmental issues related to their activities has increased (Kolk, 2000). However the type of environmental focus has changed over the years (Kolk, 2000):

> *"From a technical concern affecting maintenance and production /…/ it has evolved into an issue incorporated into logistics and purchasing decisions, and finally entering the strategic level: marketing and sales, research and development, and corporate finance"*

According to Kolk (2000), companies can take one out of four strategic approaches when working with environmental issues; reactive, defensive, accommodative and proactive. These approaches range from denying responsibility and doing less than required to anticipating responsibility and doing more than is required, Table 1.

Table 1: The four possible strategic approaches of companies according to Kolk (2000).

Type of reaction	Strategy	Performance
Reactive	Deny responsibility	Doing less than required
Defensive	Admit responsibility	Doing the least that is required
Accommodative	Accept responsibility	Doing all that is required
Proactive	Anticipate responsibility	Doing more than is required

Kolk (2000) refers to a McKinsey inquiry, stating that company focus today is primarily on complying with regulations, preventing incidents, enhancing positive image, integrating environment into corporate strategy and realizing new market opportunities. Kolk (2000) also mentions that the foremost factor influencing environmental work, according to a United Nations Conference on Trade and Development inquiry, is domestic legislation. Other important factors mentioned are companies' own legal actions, external environmental accidents and host country legislation (Kolk, 2000).

The change of operational focus, moving from end-of-pipe to process-oriented to product-oriented solutions, has created an alteration of several aspects related to environmental issues, see Table 2 (Kolk, 2000). The authors believe the areas shown in Table 2 are interconnected with SD, and will be further discussed in section 9.

Table 2: A matrix of three possible operational approaches and the differences between them according to Kolk. Change over time has moved from end-of-pipe solutions towards process-oriented and product-oriented solutions (Kolk, 2000).

	End-of-pipe	Process-oriented	Product-oriented
Focus	Disposal; clean up	Production process	Product (life-cycle)
Type of measures	Relatively simple, technical	Difficult process changes	Changes in the entire product chain
Product or process	-	Process control	Product and process design
Environmental policy / knowledge	No clear policy; not much knowledge	Policy formulation starts; knowledge builds up	Clear policy; much knowledge
Place of environmental management in the organization	Environmental department	Becomes a concern of other departments	Highly integrated
Relationship environment - strategy	Environmental concerns are not considered	Environmental concerns start to play a role	Environmental concerns are integrated
Regulation or self-regulation	Regulation; company initiatives are rare	Number of initiatives increases	Many initiatives; more self-regulation
Environmental consciousness	Limited	Increasing	High
Perception of the environment	Burden	Precondition	Challenge

2.5.2 Historical development of the industry's work with social responsibilities

In addition to environmental issues, the corporate interest in and concern for employees, customers and the society has continuously grown. The concept of corporate social responsibility (CSR) has been widely debated; some state companies should take responsibility for the societal impact caused by their operations while others see the additional social responsibility as a threat to the market economy (Grafström, Göthberg, & Windell, 2008).

In the same way as with environmental issues, the social responsibility issue sprung from a series of incidents and the publishing of books, such as Howard Bowens 'Social responsibilities of the businessman', which contributed to increased public awareness of the issues. Primarily western companies with end-consumer products, outsourcing their production to developing countries were criticized by the public. The risk of being publicly criticized made other businesses and industries take increased social responsibility for their actions (Grafström, Göthberg, & Windell, 2008).

The demands put on companies and the ideas of what social responsibility should consist of are continuously changing (Grafström, Göthberg, & Windell, 2008). The initial idea of companies as economic institutions, with the purpose of making profit, shifted during the earlier decades of the twentieth century to a more employer oriented focus, including the creation of human resource management, employee unions, and lower limits of working conditions. In the 1950's, focus shifted again,

this time towards marketing and product quality management, resulting in more extensive product information and the avoidance of marketing of unsafe products. The last shift occurred only decades after and originated from previous company charity. What was once based on a desire to do good, turned into societal demands for things like restraining from environmental degradation, providing opportunities to minority groups, promoting social justice, and acting as a social institution as well as an economic one (Kolk, 2000). Hitchcock & Willard (2009) describes the same transformation as Kolk (2000) but also include environmental stewardship and sustainability as two additional stages, see Figure 3.

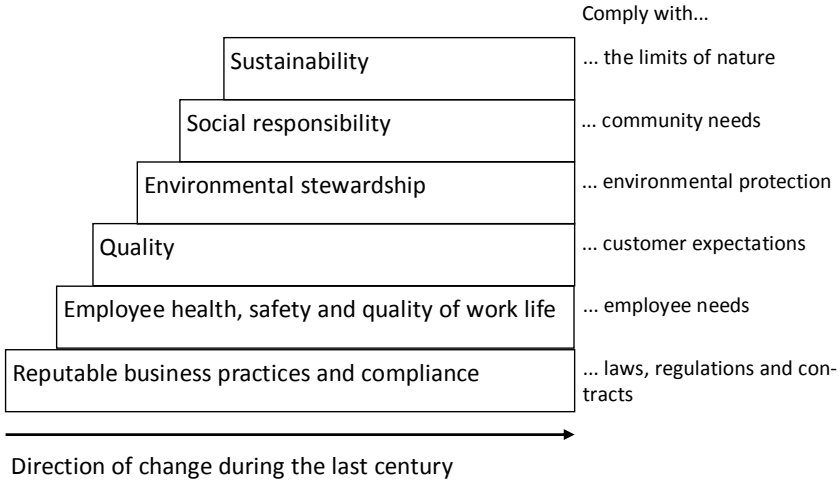


Figure 3: Hitchcock & Willard's (2009) description of the historical market transformation towards sustainability.

Grafström et al. (2008) refers to a World Economic Forum survey, stating that the underlying reasons for working with CSR are primarily to strengthen the company brand and secondarily to make the company a more attractive employer. Additionally, a global PriceWaterHouseCoopers survey shows that 72 % of approached CEOs regard social responsibility as important for profitability and 73 % believe social responsibility to have contributed to their profitability (Grafström, Göthberg, & Windell, 2008).

2.5.3 Sustainable development work in companies today

In their business guide to sustainability, Hitchcock & Willard (2009) tell of numerous possible benefits and risks of engaging in sustainability work, but also mention possible risks of not engaging in these issues, see Table 3.

Table 3: Possible benefits and risks for companies for pursuing sustainability, and risks related to not doing so according to Hitchcock & Willard (2009).

Possible benefits of pursuing sustainability	Possible risks of not pursuing sustainability	Possible risks of pursuing sustainability
Reduce energy, waste and costs	Liability for pollutants	Green washing
Differentiation	Supply problems with raw materials and energy	Cannibalizing your own product
Sidestep future regulations	Attacks on your image	Raising unrealistic expectations
Create innovative new products and processes	Legal risks	
Open new markets	Bad-mouthing of your product	
Attract and retain the best employees	Being closed out of certain markets	
Improve your image with shareholders		

and the public
Reduce legal risks and insurance costs
Provide a higher quality of life

The same business guide also states possible areas on which companies can focus their sustainability work. The manufacturing and product design industry as well as the sectors and organizational functions management, facilities, marketing, and public relations, environmental affairs, information technology, and purchasing are all relevant for engineers (Hitchcock & Willard, 2009). Hitchcock and Willard's sample of relevant industries, sectors and organizational functions are presented in Table 4 and Table 5.

Table 4: Examples of areas where companies can conduct sustainable development work in the manufacturing and product design industry according to Hitchcock & Willard (2009).

INDUSTRY
Design for environment
Minimizing packaging
Influence suppliers
Apply life cycle thinking
Energy efficiency and renewable energy
Take appropriate actions against climate change
Use resources efficiently
Reduce impacts from transportation and distribution
Regard social impacts
Reduce use of hazardous chemicals
Implement a product stewardship strategy
Waste management

Table 5: Examples of areas where companies can conduct sustainable development work in different sectors and organizational functions according to Hitchcock & Willard (2009).

SECTORS AND ORGANIZATIONAL FUNCTIONS	
Management	**Environmental affairs**
Sustainability management system	Sustainability management systems
Sustainability vision	Use of chemicals and toxics
Sustainability strategy	Water quality and conservation
Communicate and educate sustainability	Protect natural resources
Demonstrate commitment	Air quality
Embed and implement sustainability	Emergency response plans
Transparency and stakeholder involvement	Redistribute responsibility
Sustainability reporting	Hazardous waste management
Facilities	**Information technology**
Energy efficiency	Data centre management
Waste management	Efficient equipment

Landscaping for sustainability	E-waste
Incentives for alternative transportation	Dematerialization
Use green building principles	Support efficient processes
Use non-hazardous chemicals	Product design and support
Minimize the vehicle fleet	
Water management	
Marketing and public relations	**Purchasing**
Marketing strategy	Purchasing policy
Product positioning	Purchasing audits
Internal education on marketing	Influence suppliers
Marketing materials	Sustainability criteria in contracting
Stakeholder strategies	Assess progress towards sustainable purchasing
Stakeholder engagement	
Media communications	

3 Project structure

The work reported in this thesis has been conducted between September 2009 and May 2010. The project plan is shown in the Gantt scheme below, see Figure 4. The methodology is further elaborated on below.

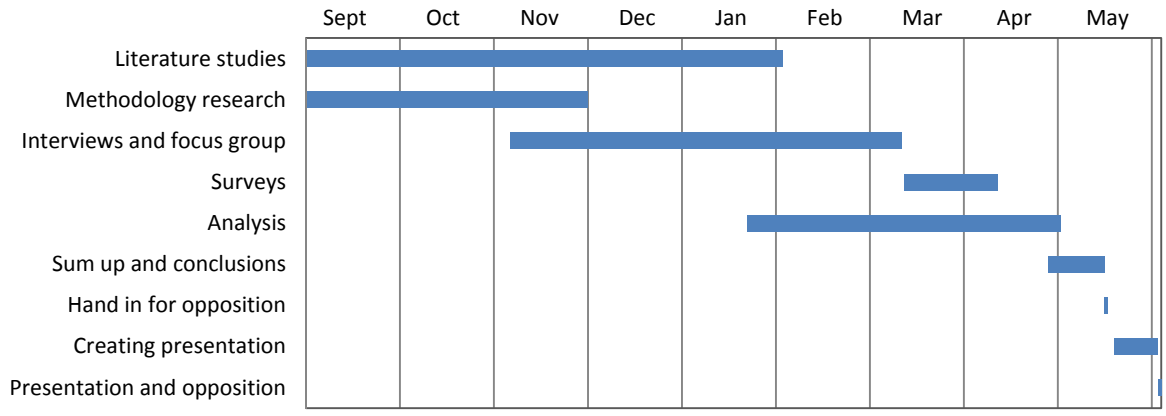


Figure 4: Gantt scheme of the project plan.

The project design can be divided into the subsequent stages; literature search, course content inventory of Chalmers education for environment and SD, interviews to uncover industry competence needs in SD, focus group discussion regarding future societal competence needs in sustainable development, alumni and student survey to verify inventory and interview results and analysis of inventory, interviews, focus group discussion, and analysis of survey results. The methodology used was of a cascading type, where the results of a previous action were used as input or tested in the upcoming action and ultimately, all results were aggregated and analyzed simultaneously, see Figure 5. All stages are further explained below. Additionally, the methods used are thoroughly explained in the corresponding parts discussed later in the report.

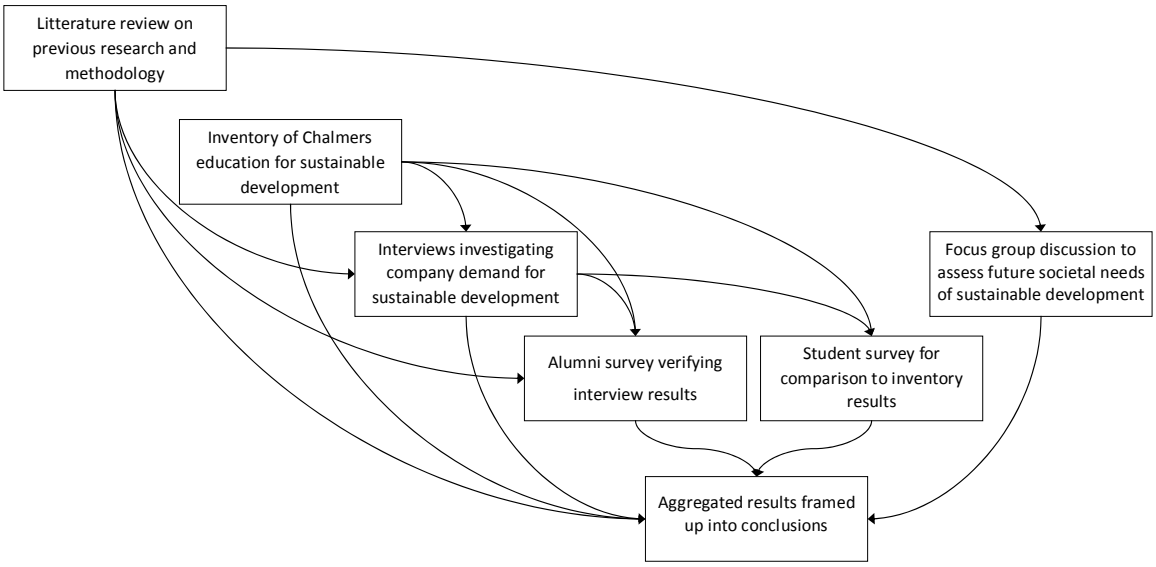


Figure 5: Description of methodology where the outputs of primary actions serve as input to secondary actions, leading towards all results being aggregated.

3.1 Literature review

The initial literature review mainly consisted of searching for what had previously been written in the field of ESD with relevance for the specific project and environmental and SD works in the industry. The initial review also included searching for good practices on how to conduct interviews, focus group discussions, and surveys, in order to choose a suitable course of action for the research. Other relevant literature was the national and local degree ordinances, Chalmers' vision and strategy documents, Chalmers' annual report, and Chalmers' indicative text for learning outcomes in environment and SD.

3.2 Course content inventory of Chalmers education for sustainable development

The course content inventory was conducted on Chalmers' mandatory courses labeled 'environment and sustainable development' on bachelor of science level, and the mandatory and recommended courses in Chalmers' five master of science programs that focus on SD; Environmental Measurements and Assessments (EMA), Geo and Water engineering (GWE), Innovative and Sustainable Chemical engineering (ISCE), Industrial Ecology – for a sustainable society (IE), and Sustainable Energy Systems (SES).

The inventory was performed in order to achieve a clear view of what areas of SD the mandatory courses mentioned above focus on. The results were discussed during the interviews with companies in order to identify a possible gap between knowledge and competences in SD supply and demand. The inventory results were also used as a base for creating alumni and student survey questions.

3.3 Interviews investigating industry's needs for knowledge and competences in sustainable development

Interviews were conducted with 16 international or national companies based in Sweden, which actively work with or show a salient effort within SD. Interviewing was selected as the method, since this method should be chosen if a deeper understanding of the topic is wanted (Gillham, 2008). The interviewed companies will be further elaborated on later in the report. The authors strived for a profound comprehension of what knowledge and competences that companies need and by conducting interviews, it is possible to "explore the reasons behind the answer" (Gillham, 2008).

3.4 Focus group discussion to assess future societal needs of sustainable development

A focus group discussion, with actors from a research institute, a non-profit organization, a national agency and an association for engineering companies, was held with the aim of speculating on future societal needs regarding SD. The result was intended to hint on what future societal needs companies may take into consideration in the future.

3.5 Surveys to verify interview and inventory results

The validity of a study can be increased by applying triangulation, using different methods to examine the same phenomenon (Höst, Regnell, & Runesson, 2006). Hence two internet based surveys were conducted in order to verify the results from the interviews and the inventory. The first survey was directed to a sample of Chalmers alumni from 2006 in order to verify the interview results. A second survey was sent to the third-year students at Chalmers to assess whether they had a good understanding of SD after taking a mandatory course in environment and sustainable development. The latter survey was to complement the alumni survey and to verify results from the inventory of Chalmers' courses in environment and SD.

3.6 Interpretation, discussion and conclusions

The process of analyzing occurred concurrently with obtaining the results from the three major research stages; the course content inventory of Chalmers education on environment and SD, the interviews investigating company demand and the focus group discussion to assess future societal needs of SD, and the surveys. This was in the end also compared to the theory collected.

" – Sustainability should be a core competence in engineering education, that is self-evident! /…/ though, it should be a natural part of the education."

- A sustainability manager at a manufacturing company [30]

Part 2: COURSE CONTENT INVENTORY OF CHALMERS EDUCATION FOR SUSTAINABLE DEVELOPMENT

An inventory of course content in Chalmers' education in environment and sustainable development has been conducted as a part of this thesis, with the aim of assessing the type of knowledge and competences students at Chalmers may acquire when studying a three- or five-year engineering program. The inventory results were later used during company interviews in order to identify a possible gap between knowledge supply and demand. This is further elaborated on in part 3. The inventory results were also used as a basis for formulating survey questions in the two surveys, to alumni and students.

4 Inventory theoretical framework

In the inventory of education for environment and SD at Chalmers, different types of course activities were categorized. There are several different rating systems and educational taxonomies available. The system created and used in this thesis for describing the depth of learning (or rather the amount of teaching) was inspired by the CDIO scale (Crawley, Malmqvist, Östlund, & Brodeur, 2007) and Bloom's taxonomy of educational objectives (Bloom, 1956). Both the CDIO scale and Bloom's taxonomy are used throughout Chalmers for course and program creation, evaluation and development. Both of these are presented below. The developed system was used for categorizing course content areas with regard to course activities. This theoretical framework is also presented below.

4.1 CDIO scale of benchmarking existing curriculum

The CDIO approach was initiated in the late 1990's at four universities around the world; Chalmers, the Royal Institute of Technology (KTH) and Jönköping University in Sweden, and Massachusetts Institute of Technology (MIT) in the US (Crawley, Malmqvist, Östlund, & Brodeur, 2007). The goal was to improve the state of engineering education, through a method called Conceive, Design, Implement and Operate (CDIO). One of the goals of the CDIO concept is to create curricula for educational programs where an integrated approach is taken, i.e. the teachers and students should have a clear picture of what courses and course contents are related to one another in a program curriculum. When a curriculum has reached this level it is called an integrated curriculum. In order to reach an integrated curriculum, a course curriculum can be benchmarked according to a scale developed for the CDIO concept, where all aspects within learning outcomes, type of learning and assessments are taken into account. The depth of the comprehension level and usage of knowledge obtained are then graded into the three parts; *Introduce*, *Teach* and *Utilize* depending on the level of the activities (Crawley, Malmqvist, Östlund, & Brodeur, 2007), see Table 6.

Table 6: The CDIO matrix used when assessing a course curriculum based on aspects within learning outcomes, type of learning and assessments, and graded into introduce, teach or utilize depending on the activities performed according to Crawley, Malmqvist, Östlund, & Brodeur (2007).

	Learning outcomes	Type of learning	Assessment
Introduce	Probably not an explicit outcome	Topic is included in an activity	Not assessed
Teach	Must be an explicit learning outcome	Included in a compulsory activity. Students practice and receive feedback.	Student's performance is assessed. May be graded or ungraded.
Utilize	Can be related to learning outcome	Used to reach other intended outcomes	Used to assess other outcomes

Benchmarking an existing curriculum is one of the foundations of creating an integrated curriculum according to the CDIO design process model (Crawley, Malmqvist, Östlund, & Brodeur, 2007). In benchmarking an existing curriculum, one analyzes all the preexisting conditions for a course or curriculum and assesses them using the scale presented in Table 6. When assessing several courses simultaneously, a set of standard definitions of the meaning of introduce, teach and utilize is produced, where all courses and curricula are assessed equally. However, it is not possible to equate the expected proficiency levels of learning outcomes directly with teaching activities, though it is possible to make comparisons and identify weaknesses and strengths across courses and curricula through the CDIO benchmarking process (Crawley, Malmqvist, Östlund, & Brodeur, 2007). In the long run, the benchmarking is meant to lead to curriculum changes which finally lead to an integrated curriculum,

where the students' achievements can be assessed. When the students' achievements have been assessed, they in turn can be used as input to a second round of benchmarking in order to improve the curriculum.

4.2 Bloom's scale of educational taxonomies

The taxonomy of educational objects developed by Bloom (1956) uses six categories; *knowledge*, *comprehension*, *application*, *analysis*, *synthesis* and *evaluation*. Each category is defined by the act it involves, see Table 7. The taxonomy aims at defining the different levels of learning in relation to usage of the material learnt (Bloom, 1956).

Table 7: Bloom's taxonomy of educational objectives, with knowledge as the lowest level of competence and evaluation as the highest, according to Bloom (1956).

	Category	Defined act
↓ Increasing level of competence ↓	Knowledge	The recall of specific and isolated bits of information
	Comprehension	What is being communicated and to able to make some use of the material or ideas contained in it
	Application	The comprehension of a situation and the correct usage of the information given
	Analysis	The meaning and intent of the material /…/breakdown of the material /…/ detection of the relationships of the parts
	Synthesis	The putting together of elements and parts so as to form a whole
	Evaluation	The making of judgments about the value, for some purpose, of ideas, works, solutions, methods, material

4.3 Course content categories

Previous sections described two methods for assessing the level of intended learning. When analyzing course contents, a separate set of taxonomies can be used. Three such taxonomies are the taxonomy by the UNESCO Chair at Universidad Polytechnica de Catalunya (UPC) (Segalàs Coral, 2008), the taxonomy by Lourdel (2005), and the taxonomy by Segalàs, Ferrer-Balas and Mulder (Segalàs Coral, 2008). The categories presented in the different taxonomies are intended to be used to study students' comprehension of SD, and its broadness and complexity. The taxonomies are presented in Table 8.

Table 8: Comparison of taxonomies for analyzing sustainable development concept comprehension (Segalàs Coral, 2008).

Categories		
UNESCO Chair at UPC	**Lourdel** (2005)	**Segalàs, Ferrer-Balas, Mulder**
1. Environmental	1. Environmental	1. Environmental 2. Resource scarcity
2. Social	2. Social cultural 3. Multidimensional approaches	3. Social impact 4. Values 5. Future (Temporal) 6. Unbalances (Spatial)
3. Economic	4. Economic, Scientific, Technological	7. Technology 8. Economy
4. Institutional	5. Procedural and political approaches 6. Actors and stakeholders	9. Education 10. Actors and stakeholders

4.4 The indicative text for learning outcomes

The indicative text for ESD learning outcomes at Chalmers, mentioned in section 2.3.2, contains the intended learning outcomes for courses in environment and sustainable development and should serve as a guideline regarding important course content areas. The present indicative text is based on the previous intended learning outcomes, see Table 9 below.

Table 9: Intended ESD learning outcomes in a course in environment and sustainable development at Chalmers according to the previous indicative text for ESD learning outcomes (Chalmers, 2005).

Previous intended learning outcomes
Recall basic facts about the state of the world regarding population growth, human needs, resources, technological systems and the problems that arise in the relation between humans and the environment.
Explain the complexity which encompasses meeting human needs within the limits of the environment, which also includes human relations, such as conflicts, inter-generational justice and democracy.
Explain the importance of long sightedness, and ethical considerations, when evaluating the sustainability of technical systems.
Communicating across professional and disciplinary boundaries.
Treat large over-arching problems by identifying manageable sub problems that can be solved by the engineer.

The above indicative text for ESD learning outcomes is intended for courses in environment and SD, and aims at empowering students with knowledge in three main areas; the description of sustainable development and some of its implications, identification and concretization of critical problems, and reflections on how the student's future role as an engineer may affect sustainable development and vice versa. The new, additional, learning outcomes in the present indicative text are presented in Table 10.

Table 10: The present indicative text stating what a Chalmers student should be able to do in regards to the education in environment and SD (Chalmers, 2009h).

After the bachelor studies, a Chalmers student should be able to:
Knowledge and understanding
Account for the concept of SD and the political ambitions behind it
Account for causes behind unsustainable development, including relevant examples of states and trends in natural and societal systems
Describe the profession's interface to natural and societal systems
Skills and abilities
Use a systemic perspective to analyze product life cycles and cause-effect chains that reach from technical systems to natural and societal systems, and be able to interpret models of these
Use problem solving, critical and creative thinking, be able to communicate and cooperate, and be able to discern power issues in different decision-making processes in order to prepare for life-long learning and for becoming an effective change agent for SD
Apply and shift between different perspectives in order to understand the situation of other stakeholders, and in order to be able to determine the viability of different options
Attitudes
Separate facts from values, identify ethical dilemmas, and be able to apply and discuss different ethical principles, and accept that judgments are based on both facts and values, and that different value bases can give different outcomes
In a structured way reflect on his or her professional role and responsibilities as a professional and as a citizen in relation to SD

5 Inventory methodology

The main objective of the inventory was to make a brief assessment of the course contents hence none of the two educational taxonomies presented in sections 4.1 and 4.2 can be used to assess the content in courses in environment and sustainable development. The authors therefore decided to create a new version, influenced by the two taxonomies presented. The authors believe the use of their own scale can be warranted since its purpose is only to make a brief assessment.

5.1 Authors' scale

The authors' scale was used to make an inventory of the SD related content in courses and is mainly influenced by the Bloom taxonomy and the CDIO scale presented in section 4. Elements from the two categories synthesis and evaluation in Bloom's taxonomy were used. The CDIO definitions of type of learning in the three different categories, introduce, teach and utilize were altered slightly to fit the authors' needs. The main objective of the authors' scale was only to assess single course contents. Instead of assessing overall course objectives, such as "the students are taught sustainable development in this course", the authors wanted to assess whether or not the course e.g. "introduces the concept of Life Cycle Assessment" or if the course lets the students "utilize Cost Benefit Analysis".

The authors own scale is based on five different levels corresponding to type of learning in the assessed courses. In order to assess basic introductory material, knowledge only assigned to one lecture was rated as one and knowledge assigned to a low number of lectures or was a recurring topic was rated as two. This corresponds to the category 'introduce' in the CDIO scale and 'knowledge' and to some extent 'comprehension' in Bloom's taxonomy. Knowledge assigned to a large number of lectures and/or a project was rated as three in the authors' own scale and corresponds well to the category 'teach' in the CDIO scale and 'application' in Bloom's taxonomy. Knowledge assigned to an entire course was rated as four in the authors' scale, which roughly corresponds to the category 'utilize' in the CDIO scale, and Bloom's 'analysis' and 'synthesis'. Knowledge assigned to an entire bachelor or master thesis was rated as five which also corresponds somewhat to the CDIO scale category 'utilize', but also to Bloom's two categories 'synthesis' and 'evaluation'. The authors' scale is presented in Table 11 and Figure 6 presents a schematic comparison of the three different systems; authors' scale, CDIO scale and Bloom's taxonomy.

Table 11: The authors' own scale of type of learning. Rating 1-4 have been used during the course assessment. No courses were given a rating of 5 since it is highly dependent on the bachelor or master thesis at hand.

Course content	Rating
Knowledge assigned to one lecture	1
Knowledge assigned to a couple of lectures, or a recurring topic	2
Knowledge assigned to a large number of lectures, and/or a project	3
Knowledge assigned to an entire course	4
Knowledge assigned to an entire bachelor or master thesis	5

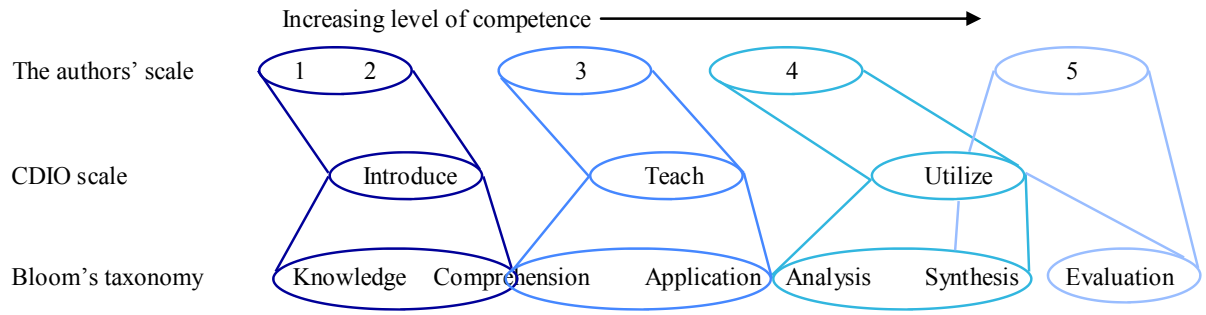


Figure 6: A schematic comparison of the authors' own scale, the CDIO scale and Bloom's educational taxonomies.

5.2 Method of analysis

The inventory was conducted by collecting learning outcomes, course memorandums, schedules and project memorandums for relevant courses and programs. Course handouts and lecture notes were also analyzed where available. The collected material was then assessed using the authors' scale, by looking through all of the available course material. Last, the course contents collected were entered into a spreadsheet where the different course contents were rated using the authors' scale from one to five.

The inventory resulted in an identification of 157 different types of relevant course contents, which were aggregated into nine categories, and later amended by two additional categories after the company interviews. The eleven categories were used to assess course content and program content in SD, and enabled a comparison between different programs, courses and course contents. The categories were loosely based on the categories outlined in section 4.3, but they were altered to fit the course contents in a reasonable manner. The eleven course content categories can be found in Table 12.

5.3 Delimitations

The inventory was only based on available learning material and not actual learning outcomes. The authors did not look through course literature that was not available by downloading; hence almost no course literature, such as books, was evaluated.

The results are based on the course content in 69 different courses taught at Chalmers, both at bachelor and master level. The inventory includes the mandatory courses on bachelor level which are stated to include the topic environment and sustainable development. The courses correspond to the contents identified as the course content in the bachelor levels that are to meet the 7.5 hec requirement. Some program descriptions have not clearly specified which of the courses that contain environment and sustainable development, hence the courses that appeared to be SD courses were chosen. Additionally the inventory includes the five master programs with an emphasized focus on SD; IE, EMA, SES, ISCE and GWE. The master program inventory included all mandatory, recommended and optional courses with a distinct focus on environment and sustainable development. The inventory disregarded the potential carrying out of a master thesis within the area of SD since this learning activity is individual hence no course element received a rating of 5 according to the authors' scale.

6 Inventory results

The results derived from the inventory can be divided into two parts. One part lists the 157 different course topics covered in Chalmers' bachelor and master courses in environment and sustainable development. The other part is the summation of course contents for each program and a calculation of the amount of teaching.

6.1 Course contents and content categories

In order to analyze with the course contents in a manageable way, the authors grouped the different course contents into what eventually became eleven different categories. The categories made it possible to connect results from both company interviews and survey results to the inventory. The eleven different categories are presented in Table 12 together with a short description of different topics that were placed by the authors in that category. The number of topics within is each category is shown in the last column of Table 12. The category "Communication" is given a zero since the authors did not identify such course content in any of the analyzed courses. A complete list of category contents can be found in Appendix E.

Table 12: Course content categories in Chalmers' courses on environmental and sustainable development. The right-most column shows the total number of topics identified within each category.

Category	Type of learning	Sum
Environment	How the natural systems work, i.e. climate change, ecosystems, environmental chemistry, pollution and energy transport.	37
Assessment tools	Different tools for working environmentally friendly, or to evaluate environmental or social impacts through methods such as Life Cycle Assessment, Design for Environment, risk assessments and Cost Benefit Analysis.	59
Resources	Resource use and knowledge in what resources can become critical in the future. Also energy and material as resource and/or waste reduction.	28
Economic aspects	Discounting, investments, innovation economics and technological development.	12
Management	Knowledge in environmental management systems like ISO 14001, understanding of SD reports and indicators for SD.	9
Politics and policies	Knowledge in present and coming policies and regulations concerning sustainable development and how they affect companies and organizations.	10
Green technologies	Knowledge in new technologies seen as more environmentally friendly than the present ones, and also other upcoming technologies such as PV cells and CCS.	29
Social impacts	Presenting a company's work towards society, i.e. Corporate Social Responsibility, ecotoxicology, human health issues and behavioral sciences.	14
Values	Presenting business ethics surrounding sustainable development, like inter and intra generational justice, and equity between developed and developing countries.	8
Stakeholders	Knowledge in a company's stakeholders through the supply chain to the end consumer.	7
Communication	Giving better understanding for sustainable development in regards to communication over professional groups to make the communication regarding SD more comprehensible.	0
Category	Type of learning	Sum

The course content categories used throughout this thesis can be further aggregated in a similar way as presented in Table 8. Three of the four over-arching categories were used in this thesis; *environment*, *economic*, and *social*. Communication is the only category that was not categorized according to the three over-arching categories, due to no obvious placing. In Figure 7, the relations between the different over-arching categories and the subcategories are presented.

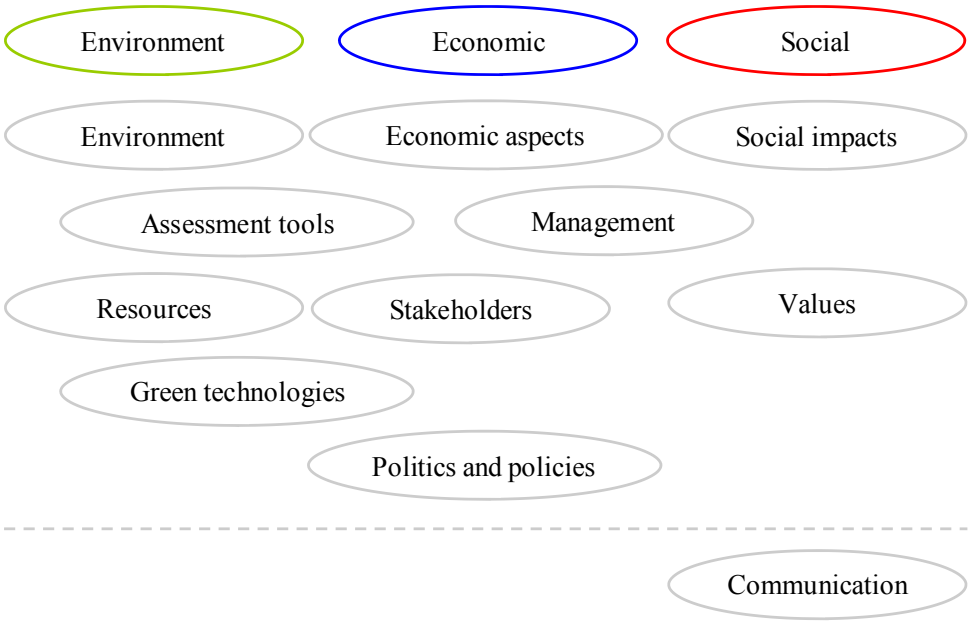


Figure 7: The course content categories used throughout this thesis, and their connection to the over-arching categories.

6.2 Course content in different programs

The categories were used to analyze to what extent different courses and programs teach environment and sustainable development. Since the course contents were given an index of 1 to 4, it is possible to arrange courses according to the amount of each category presented in the course. The result for eight different bachelor programs and five master programs have been selected to be presented. This selection was based on their respective course content, and the results of the authors' student survey.

6.2.1 Bachelor program course contents

The eight bachelor programs chosen were *automation and mechatronics engineering*, *chemical engineering*, *civil engineering*, *computer science and engineering*, *electrical engineering*, *engineering physics*, *industrial engineering and management*, and *mechanical engineering*. The bachelor programs either have one course that has been identified as an environmental and sustainable development course, or several courses which have integrated SD elements. The number of courses identified and analyzed in the different programs can be found in Table 13. The courses have been identified through program descriptions and through a similar inventory made in 2007 by Lundqvist & Svanström (2008) at Chalmers.

Table 13: The number of analyzed courses in the bachelor programs. A full list of which courses that have been analyzed can be found in Appendix F.

Bachelor program	Analyzed courses
Automation and mechatronics	4
Chemical engineering	5
Civil engineering	1
Computer science and engineering	1
Electrical engineering	1
Engineering physics	1
Industrial engineering and management	5
Mechanical engineering	5

The results from the bachelor program inventory can be seen in Figure 8 and Figure 9. In Figure 8, the course contents are presented for each program. The results from Table 13 should be correlated to Figure 8, where it is shown that chemical engineering and mechanical engineering have a high amount of SD course contents, which can be expected since both programs have five different courses where SD is integrated. Programs with fewer courses in SD, like engineering physics show a lower amount of course contents in Figure 8. Environment is the most evident category in most of the bachelor programs.

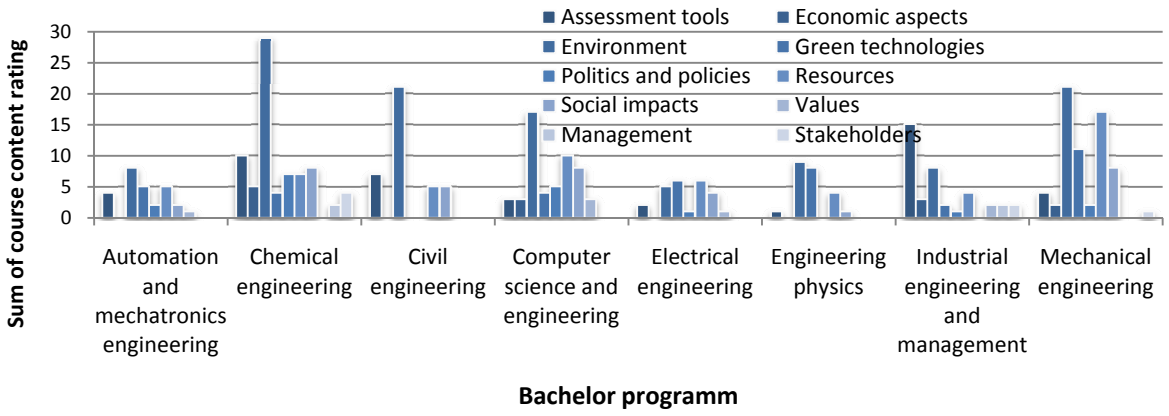


Figure 8: Course content on environmental and SD in eight different bachelor programs. Note that the environmental content bar (third from the left) is highest in all programs but electrical engineering. The chemical engineering program, computer science and engineering program, and mechanical engineering program all score high on many of the different course contents.

Figure 9 presents the same results but instead sorted by category. Again, it is evident that the category 'environment' ranks highest. The second highest ranking category is 'resources' followed by 'green technologies', with 'assessment tools' as fourth. These four categories are the most prominent according to Table 12 however the category 'assessment tools' in the same table has the most course contents. This shows that the category 'assessment tools' is a broad issue with high number of topics included. However due to the weighting, by rating the topics, this does not necessarily correspond to a high ranking compared to categories with a narrower topic but taught more in depth.

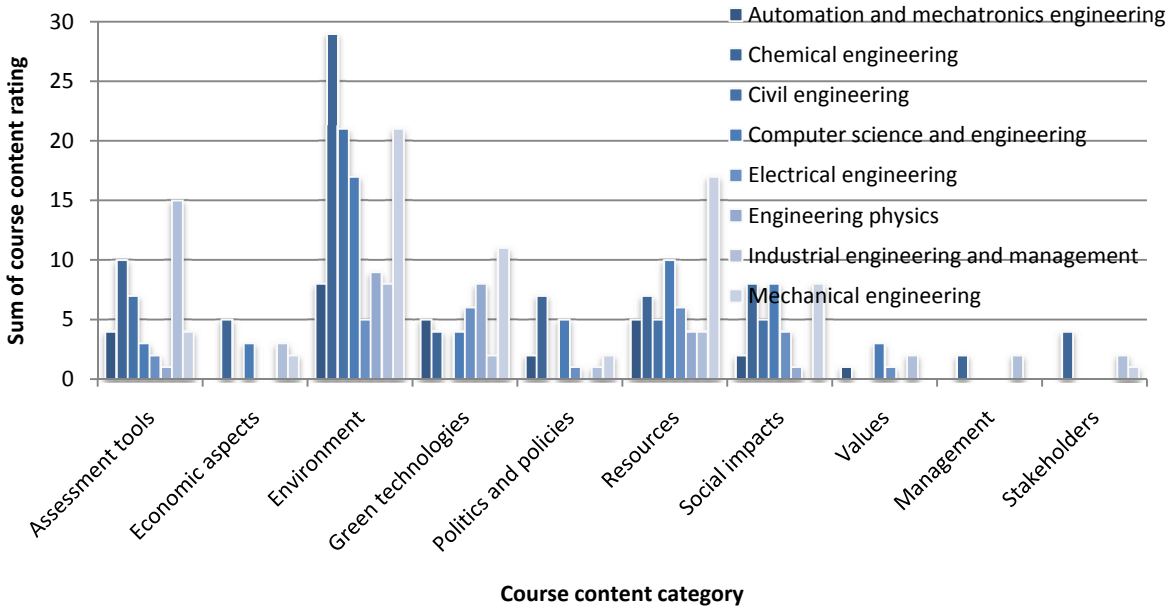


Figure 9: The focus of course contents in environment and SD in eight bachelor programs. All mandatory bachelor courses were taken into account.

6.2.2 Master program course contents

The same analysis as for the bachelor programs was conducted for the master programs. The first analysis assessed all master program courses, mandatory, recommended and optional. The reason for assessing recommended and optional courses in addition to the mandatory was due to the master program ISCE which does not have any mandatory courses, only recommend ones. In the complete analysis, the master program which ranks the highest is IE with a large amount of course contents covering 'assessment tools', 'environment', 'green technologies' and 'resources', see Figure 10.

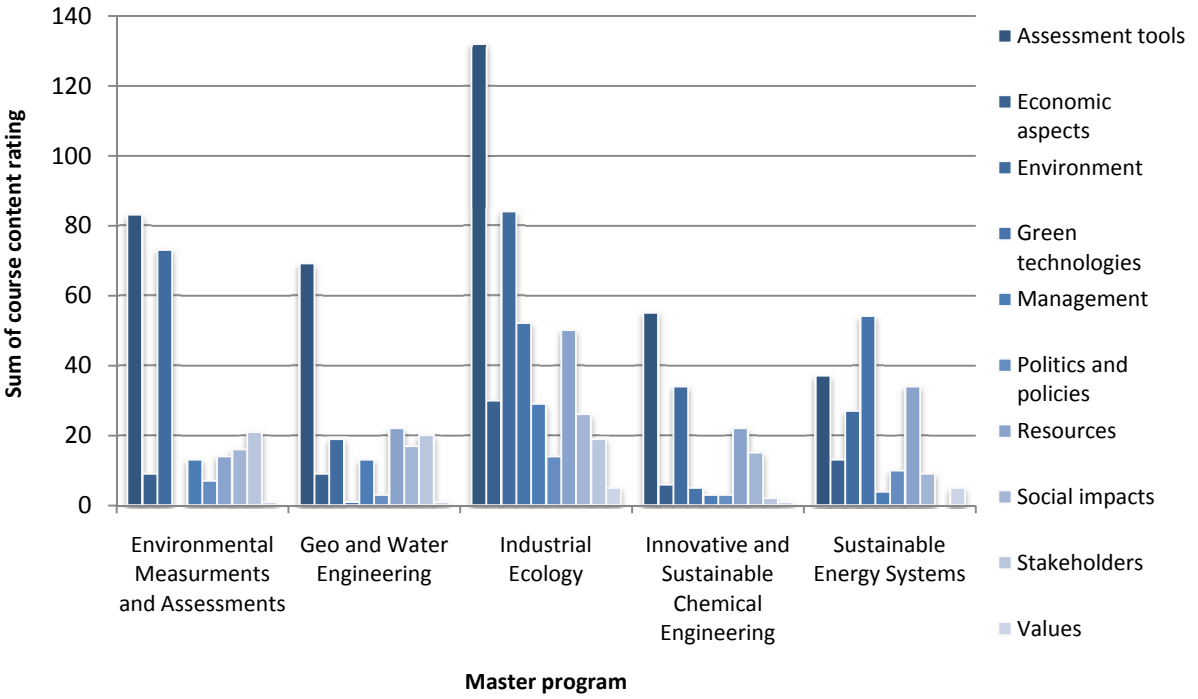


Figure 10: Master program course contents in environment and SD, sorted by program. This figure shows all course contents on environment and SD in all master programs, both in mandatory, recommended and optional courses.

When looking at these results from a course content perspective, it is obvious that the master programs put great emphasis on 'assessment tools', especially assessment tools that are relevant within the specific discipline. Additionally, course contents emphasized are 'environment', 'resources', and 'green technologies' respectively, see Figure 11. This corresponds fairly well to the focus of the bachelor programs, see Figure 9.

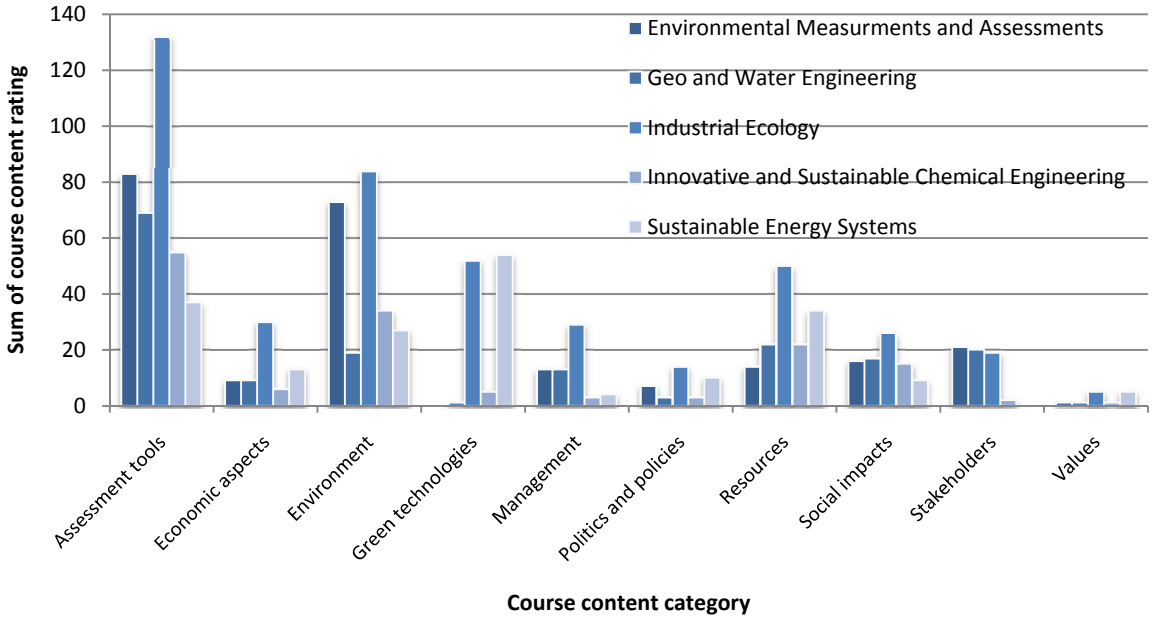


Figure 11: Master program course contents in environment and SD, sorted by course content categories. This figure shows the course contents in all mandatory, recommended and optional courses.

Figure 10 and Figure 11 show that the program IE takes many of the categories into account in the mandatory, recommended and optional courses. In order to expand the discussion on the figures above, data for three master programs have been divided into the four first rating levels in the authors scale (1-4) and related only to mandatory courses in the respective master programs. The selected master programs are IE, EMA and SES.

Taking a look at the mandatory courses gives a somewhat different picture of the master programs, where assessment tools have become much less important in the master program IE, which can be seen in Figure 12. This is due to that assessment tools are mainly focused on in the recommended and optional courses.

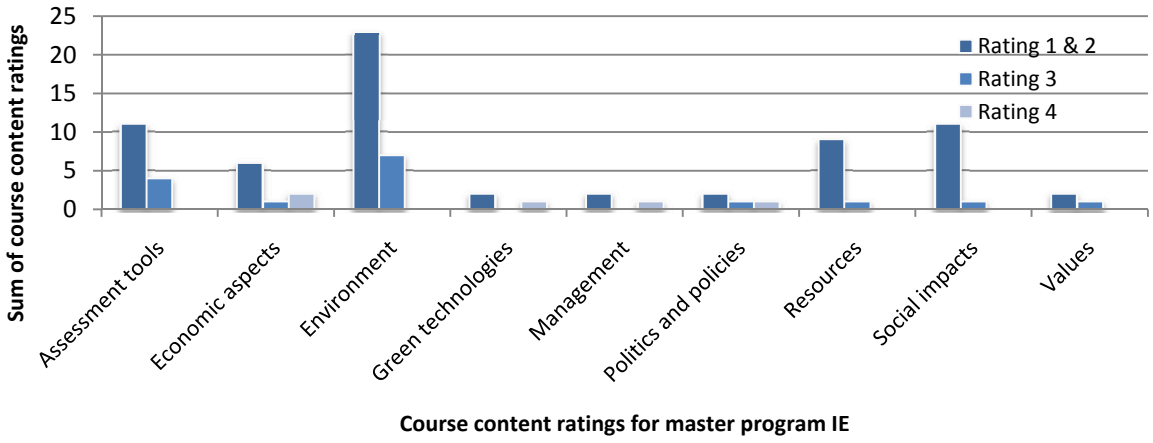


Figure 12: Course contents in the mandatory courses in the master program *Industrial Ecology*. The different bars represent the different categories outlined in the authors' scale for rating course contents presented in section 5.1.

Conducting the same analysis for EMA shows that 'assessment tools' are more focused on in the mandatory courses in comparison to IE. The category 'environment' also plays an important role, see Figure 13. The category 'environment' is more emphasized on rating level 3 at EMA than at IE, where

category 1 & 2 are more prominent. This means that the issue, is to a larger extent, assigned to a large number of lectures, and/or a project at EMA, than mostly assigned to one lecture and/or to a couple of lectures, or a recurring topic at IE.

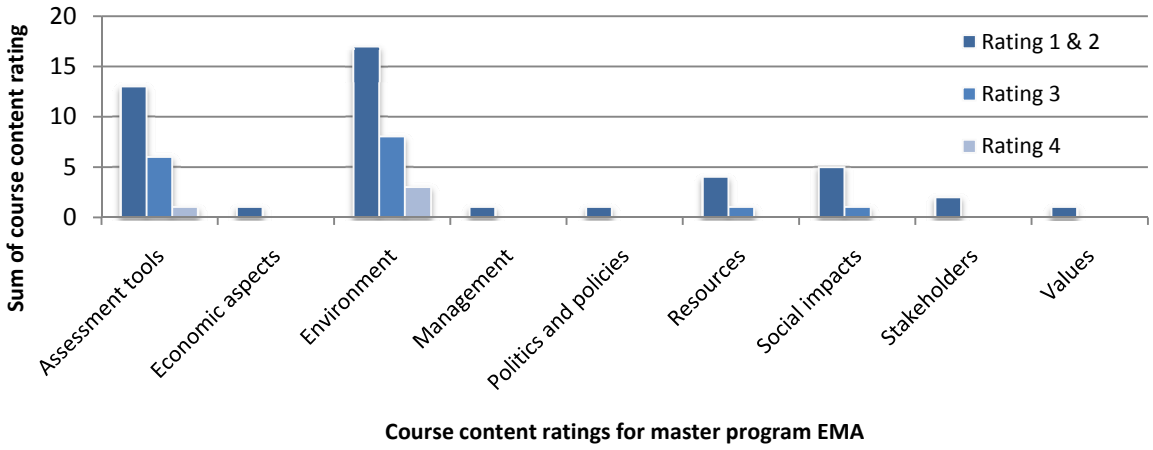


Figure 13: Course contents in the mandatory courses in the master program *Environmental Measurements and Assessments*. The different bars represent the different categories outlined in the authors scale for rating course contents presented in section 5.1.

Taking the same approach for SES reveals a larger emphasis on 'green technologies', which is to be expected from a master program on energy systems. 'Resources' also plays a more important role in this program, which can be seen in Figure 14.

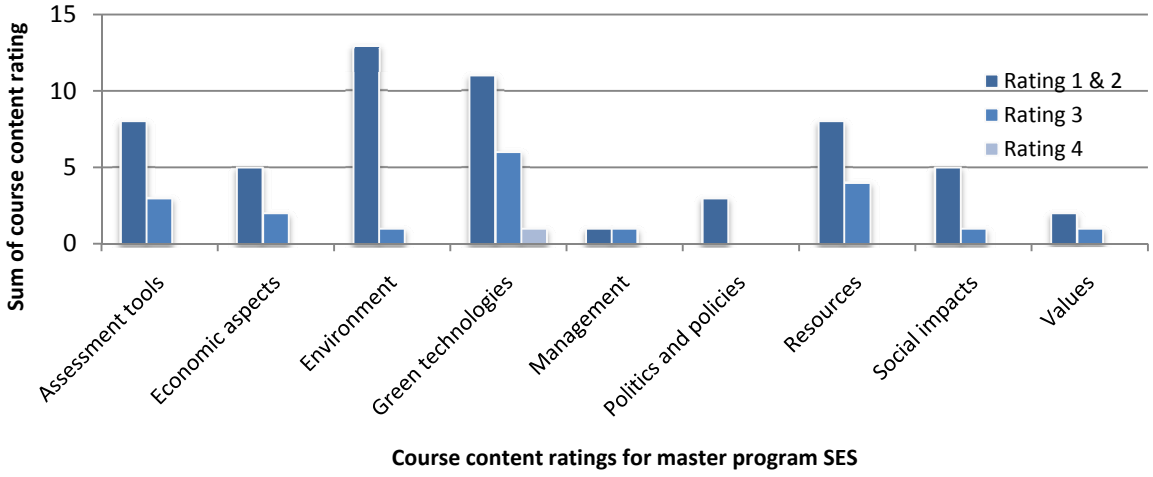


Figure 14: Course contents in the mandatory courses in the master program *Sustainable Energy Systems*. The different bars represent the different categories outlined in the authors scale for rating course contents presented in section 5.1.

The results show that the different programs put emphasis on different categories. Looking at all three programs the categories 'green technology' and 'environment' are most commonly applied ratings 3 and 4. In SES (Figure 14), 'green technologies' rank highest, and for EMA (Figure 13), and IE (Figure 12), 'environment' ranks highest. Nevertheless, at IE, categories rated as 4 are spread across a large number of courses.

7 Quality of the inventory

The inventory was built upon electronically available course memorandums, project memorandums, lecture slides and schedules. However, the information available was of varying quality. The inventory was thus based on what opportunities are given to students to grasp, rather than a measurement of what knowledge students have acquired when graduating.

Since the analysis was based on the information available to students, the results of the analysis can be related to what information a student can apprehend if the student does not attend the lectures and only rely on handouts and lecture notes. The lecture notes most often mirror the contents of the course in a good manner, and thus the results are valid in that context.

In some courses teachers have not used PowerPoint presentations for their lectures, and handouts may be scarce, and this may have given a skewed picture of the reality compared to courses with plenty of material available. This has been somewhat balanced by an analysis of course content according to the course memorandums and through a comparison with the analysis made by Lundqvist and Svanström (2008) since this was based on interviews with relevant program coordinators, examiners and lecturers.

Since the authors' own scale only assesses the type of learning, it is not compliant with the two other scales; CDIO and Bloom's, only influenced by them. However, the aim was only to make a rough assessment of course contents, and not actual learning outcomes, hence the authors concluded that the method is valid.

" – We need engineers to be engineers, but we also need them to be engineers that can do things in a sustainable way, a green way, an ethical way and a safe way. /…/ If they are not educated about how to do this, then they would be educated for the past, not the future."

- A senior vice president for sustainability at a consultancy/ construction company [5]

Part 3: INTERVIEWS TO UNCOVER INDUSTRY AND SOCIETAL COMPETENCE NEEDS IN SUSTAINABLE DEVELOPMENT

This thesis is mainly based on several interviews and one focus group discussion conducted with relevant companies, organizations and other individual actors. The interviews and the focus group were conducted to assess the present and future needs of competences in sustainable development in the Swedish industry and the Swedish society. The interview template used was mainly based on the literature review and the inventory results. The results from the interviews were used as a basis for creating the two surveys presented in part 4, and as a mean to analyze the inventory presented in part 2.

8 Interview and focus group theoretical framework

Both an interview and a focus group discussion can be seen as a systematic questioning on a specific topic. Interviews and focus group discussions aim at retrieving qualitative information hence there is no need for a random sample if the aim is not to generalize the results. However the sample should represent the range of the population targeted. The population should therefore be categorized and the sample should be representative of all categories (Höst, Regnell, & Runesson, 2006).

8.1 Semi structured interviews

Semi structured interviews were chosen due to the method's possibilities of comparison and depth at the same time. A semi structured interview is a flexible method with enough structure in order to give high quality data. The method however is very time consuming, demands a great amount of preparation, and may be difficult to analyze and interpret (Gillham, 2008). A semi structured interview is a mixture of fixed and attendant questions. The fixed questions are always asked all of the interviewees in the same way in order to not affect the interviewee and to facilitate comparison between different interviews (Höst, Regnell, & Runesson, 2006). The attendant questions help the interviewer to make sure all interviews touch on the same issues and to explore some issues even further (Gillham, 2008).

All interviews should be approximately of the same length and the interview questions should be tested on the same type of person as the interviewees in advance to optimize the interviews (Gillham, 2008).

8.2 Focus group discussions

Focus group discussion was chosen as a method since the interaction between the participants can create synergies. It is useful in the early stages of a research and gives an early hint of the possibly different views present. The actual discussion can however be difficult to control and the data may be cluttered and incomplete (Gillham, 2008).

Focus group discussion can be defined as "a technique where data is collected through group interactions surrounding a topic predefined by the researcher". The group should consist of persons that do not know each other from before and the discussion should be held as a formal meeting, with time and place decided by the researcher (Wibeck, 2000). The group composition affects the results hence the group should consist of 6 to 10 people who have a personal or professional interest in the issue or have experience in the topic (Gillham, 2008). The discussion should be held by one or two facilitators and based on partly structured questions (Wibeck, 2000). Using two facilitators ease the responsibility to maintain the discussion and analyze and interpret at the same time (Gillham, 2008). The facilitator's role is mainly to keep the discussion going and to make sure the participants keep to the topic (Wibeck, 2000).

8.3 Analysis of qualitative data

Qualitative data is based on words and descriptions rich in nuances and details, and should be analyzed based on the three stages sorting, categorizing and comparing methods (Höst, Regnell, & Runesson, 2006). The analysis should be based on the purpose of the study consequently the interview questions are often used as areas of analysis however other often occurring subjects may also be included as areas of analysis (Wibeck, 2000). The analyzing method should be chosen based on the level of structure of the interviews, and structured interviews should be analyzed by categorizing the material collected (Gillham, 2008).

A categorizing analysis consists of three stages; labeling, categorizing and making comparisons, and searching for contrasting data, trends, and patterns. The first stage involves dividing a part of the transcribed material into smaller segments with common content, and applying appropriate labels. The

second stage involves compromising the different labels into suitable categories (Wibeck, 2000). The categories may be further differentiated by subcategories (Steinar, 1997). The categories may overlap with the interview questions. The third stage involves analyzing the different categories or interviews one by one. The former, analyzing the categories one by one, is chosen since it is more appropriate when conducting several interviews based on the same topic (Wibeck, 2000). The subsequent material collected are then labeled and categorized accordingly to the subcategories defined (Steinar, 1997). The aim is to interpret the data categorized and present the conclusions drawn with supporting quotes from the interviews and focus group (Wibeck, 2000).

The overall quality of the interviews is increased by certain characteristics of the interviewer; knowledgeable, structured, articulate, friendly, sensitive, open, in control, critical, good memory and analyzing habit (Steinar, 1997).

The collected data are valid if the observed results correspond to the research questions and research purpose. To ensure high validity it is important that the interviewees are honest during the interviews hence the venue of the interview and the number of participants may make a difference. It is however up to the interviewee to decide whether to trust the data collected or not (Wibeck, 2000).

High reliability of the results is important when using qualitative material since an analysis is never without the researchers' subjective interpretations. It may also be difficult to be neutral as an interviewer, and disregard previously obtained results when interviewing, since humans tend to see patterns that confirms what she wants to see and disregard contradictory information. To ensure a verifiable result it is important to follow a predefined systematic method throughout the analysis and to document all data collected, since the data collection and analysis are often parallel processes (Wibeck, 2000). Hence reliability of results obtained can be achieved by different means such as documentation, feedback, third party review and triangulation (Höst, Regnell, & Runesson, 2006; Wibeck, 2000). Using the same interviewer for all data collections reduces the problems with differently stated questions and misinterpretations during interviews. By saving all input data and analyzed results it is possible to, in hindsight, reproduce the processes and examine how interpretations were done (Wibeck, 2000). It is also to recommend that the labelling as well as analyzing are simultaneously made by more than one person and then compared to enhance the reliability of the labelling and analyzing (Steinar, 1997). The final results should also be reviewed by an impartial researcher. Due to the nature of the qualitative analysis of the semi structured interviews it is not recommended that any general conclusions are drawn (Wibeck, 2000).

9 Interview and focus group methodology

The following sections describe the methodologies used for the interviews and the focus group discussion conducted, and for the analysis of the respective methods.

In total 38 people representing 23 companies and organizations were interviewed, either individually or as members of a group. The interviewees are anonymous however the characteristics of all interview and focus group participants are given in Appendix A. A full list of which companies and organizations have been interviewed is presented in Appendix D.

9.1 Interviews investigating company demands

A selection of companies was chosen based on size of organization and type of business. The aim was to contact large organizations present in several Swedish cities, and to include all types of businesses Chalmers educational programs correspond to. Altogether the companies represent the entire range of type of engineers educated at Chalmers, see Appendix D for companies interviewed. The selection of

companies was based on marketing of the companies at job fairs. Several company representatives were approached by the authors at job fairs at three Swedish universities; Chalmers, KTH and The Faculty of Engineering at Lund's University. The authors decided to move forward with the companies whose representatives were openly positive towards the master thesis and could provide the authors with a further contact inside their respective company. The job fair catalogue listing companies and contact persons were also used. The selected companies were contacted, introduced to the project and asked to participate in an interview. The companies were primarily contacted personally in order to increase the level of participation and interest from the companies, and afterward given written information electronically, see Appendix C for letter to the companies. In total 18 companies were contacted whereof 16 wanted to proceed with an interview.

The cooperation was voluntary and the companies contacted were free to contribute with as little or as much time as they could spare. Most companies contacted were positive towards the research and contributed with both employees and time, and the two companies which denied cooperating did so due to time constraints. Most individual and group interviews were conducted with one to two employees participating however one company participated with ten employees in total.

The authors contacted employees working directly with SD, which were mostly SD managers and environmental managers. Those who participated in interviews were then chosen by the managers which resulted in a variety of professions interviewed. The interviewees are anonymous but their work functions are listed in Appendix A. The authors mainly asked to meet engineers who directly or indirectly work with SD and employees who know what competences are asked for and thus needed by the company. All interviews took place at company venues and lasted for approximately an hour.

The interviews were semi structured with a premade interview template to ensure that the same type of questions were discussed in each interview, for the full guide see Appendix B. The topics chosen for discussion were the company structures today, education, communication, competence, the presence and the future and competence categories available at Chalmers today. The idea was to address what competences the companies feel are important and what competences might be missing in engineering education today. The interviews also focused on the future role of engineers and what companies foresee as being future competence needs. Most interviews were recorded but some of them were only concurrently written down due to wishes by the interviewees. All recording were erased after summarized in text. The interviews were held by both authors in order to create a pleasant environment which encouraged everyone to discuss. If recording was not used during the interview, one author asked the interviewee questions while the other author took extensive notes.

9.2 Focus group discussion to assess future societal needs of sustainable development

It was also the aim of the authors to investigate the future societal needs of SD. This was done by conducting a focus group discussion which gave insight in how SD may possibly develop in the future. Additionally, interviews with crucial agents within the field were held with those who could not participate in the focus group discussion. In those cases the results from the focus group discussion were presented in order for the crucial agents to give additional feedback on the discussion. The focus group participants and additional interviewed crucial agents are anonymous however their professional environment is given in Appendix D and their function or characteristics are given in Appendix A. The actors contacted were either authors to relevant EESD articles, found at the three university job fairs visited, found through internet research or official representatives at national agencies. Two actors contacted declined participation. All actors had professional experience related to the topic. The focus group discussion lasted for an hour and the aim was to identify in what direction company resources may be directed in the future. The facilitators used an interview template with structured questions to make

sure the participants did not deviate from the topic chosen. Otherwise the participants were free to discuss amongst themselves.

The participating actors were university professors and researchers from Chalmers, Delft University of Technology (TUDelft) and Blekinge institute of technology (BTH); and representatives from the Swedish Defense Research Agency (FOI), the Swedish National Agency for Higher Education, the Association of Swedish Engineering Industries (Teknikföretagen) and The Natural Step. The majority of the above mentioned actors participated in the focus group discussion.

9.3 Analysis of interviews

The first stage of the analysis was conducted by examining three separate interviews and searching for common areas of discussion. The identified areas were given appropriate labels. The labels were compromised into seven categories with each label representing a subcategory. Each subcategory is given in the table below and an overall statement showing on what conclusions may be drawn from the entire category is also given, see Table 14. Subsequently, the rest of the interviews were divided into the appropriate categories and subcategories. Each category was analyzed separately and the overall result was compiled in the end.

Table 14: Category explanations and definitions of subcategories.

Category	Possible conclusions to be drawn from category	Subcategories
Company structure and view on sustainable development	The structure of the organization and the organization's view of sustainable development can depict companies' priority of the topic	If there is a team working with sustainable development and if it is an integrated or a separate department
		If sustainable development is viewed as an integrated or separate issue and if all three aspects of sustainable development are equally emphasized
		If there is support from the management regarding sustainable development issues
Responsibility of education and the need of generalists or specialists in sustainable development	What institution that bears the responsibility of education and what types of engineers that are demanded for can depict how universities should act	Which institution that possess the responsibility of ensuring adequate knowledge amongst employees, universities or employers
		If general or specialist competence demanded for in the field
Company timeframe and business goals on sustainable development	The company timeframe of sustainable development work and set goals can depict whether the company regards sustainable development issues as established issues or not	
Business reasons for working with sustainable development and how companies work with the issues	The uses of the concept of sustainable development may depict the underlying reasons to why companies work with sustainable development issues today	
Company communication and employees' understanding of sustainable	The presence of a comprehensive view and systems perspective can acknowledge an understanding for sustainable development issues. Problems with communication as well	If comprehensive views and system perspectives are applied within the organization
		How well the communication regarding sustainable development issues works

development	as if sustainable development is regarded as an intangible issue may depict a lack of knowledge regarding sustainable development issues	If sustainable development issues are viewed as tangible or intangible
Company outlook on future sustainable development issues	Sustainable development tools and concepts used today and company visions of the future may depicts what areas of knowledge that are most vital today and in the future	The organizations' vision of the future
Tools, methods and concepts for sustainable development utilized by the companies	Expressions and concepts mentioned	
Category	**Possible conclusions to be drawn from category**	**Subcategories**

9.4 Analysis of focus group discussion

The focus group discussion was analyzed separately and not in conjunction with the interviews. The transcribed material from the discussion and the additionally collected feedback from the actors absent from the focus group discussion were compared and compiled into a summarized text. Since the aim of the focus group is to give an insight in possible future societal demands of SD all thought and ideas from the participants are relevant and thus valid to include.

9.5 Delimitations

The relevant delimitations made are the companies and interviewees targeted. Due to time constraints the authors decided to only contact companies officially working with environmental and social issues today. The employees primarily contacted were mainly SD managers.

10 Interviews and focus group results

Sections 10.1 to 10.7 present the compiled results from the interviews by each category. Section 10.8 presents the summarized result from the focus group discussion. Relevant quotes supporting the results are presented, and all quotes are connected to the interviewees' professional role, type of business and a number corresponding to the list of interviewees in Appendix A. The majority of the quotes are translated into English by the authors.

10.1 Company structure and view on sustainable development

The first category discussed the structure of the company and its view on SD. The underlying reason for investigation was to see whether SD is a prioritized topic or not. The first subcategory deals with how the team working with SD, environmental and social affairs act, and if they work in a well integrated or separate department. The second subcategory deals with how SD is viewed, as an integrated or separate issue, and if all three aspects of SD are covered. The third subcategory investigates what type of management support the SD issues invoke.

Out of the 16 interviewed companies, there are different approaches on how to work with SD issues. The authors identified two different views regarding what aspects of SD companies work with and if they are integrated:

1) Five companies tend to **all three aspects** of SD; economic, social, and environmental issues though not necessarily weigh the issues equally. In these companies, it is common that environmental and social issues are dealt with in different departments.

> *" – [We need] to think about environmental issues as a part of the decision-making process which affects long-term market shares and costs /…/ but also consequences such as societal impact /…/ all decisions have to incorporate environmental, economic and social aspects /…/"*
>
> - A sustainability manager at a manufacturing company [24]

> *" – The social aspects are important in order to build legitimacy"*
>
> - A corporate responsibility manager at an energy company [13]

2) Eleven companies **only tend to economic and environmental** issues. Some of the companies see social issues as hard to deal with, since it is more difficult to calculate on social impacts than environmental and economical, and thus harder to grasp.

The majority, 12 of the 16 interviewed companies, explicitly mentioned economic issues as being fundamental and permeating all other issues since a company is an economic institution required to make a profit. They view economic aspects as being a prerequisite for working with SD issues, but do not regard economic aspects to be SD related issues.

> *" – We have to be profitable, thus the economic aspect cannot be magically wished away, since it is the basis for all decisions."*
>
> - A sustainability manager at a manufacturing company [25]

> *" – We have a strong business focus in our company, but the economic aspect is not directly connected to sustainable development, it just supersedes the issues."*
>
> - A sustainability project manager at a retail company [31]

The most common way for the companies to organize their SD efforts, 13 out of 16, is to have a central core function acting as a support function while the actual SD work is to be conducted throughout the company departments. The central core functions most often consist of a small group of employees, working as a support function, which relies on local environmental or SD coordinators.

> *" – [We] are only a support function to those who /…/ work with sustainable development"*
>
> - A corporate responsibility manager at an energy company [13]

Two companies work with a hybrid model of a central SD function and sole employee responsibilities, creating greater gain for the companies.

> *" – You either create a SD function, or you integrate it into the core business functions. We have a hybrid model, which is the best way to describe it /…/ We have got a very small team working on this, since our philosophy is to put the experts into the businesses and to influence that, but not to own it"*
>
> - A senior vice president at a consultancy / construction company [5]

" – We have moved towards a more integrated business model /…/ because the gain is greater. If you work with the issue throughout the business you will get a far greater result than compared to having a group of specialists working on it alone"

- A sustainability project manager at a retail company [31]

Additionally, there are examples of companies which do not engage in a central SD function but where it is up to each and every employee to be responsible for the SD work conducted.

" – You cannot have a central function where you think that SD is created or watched over. There is no meaning in that; you will rather get the opposite instead, meaning that everyone just drops the issue. It is each and every employee's job to mind the SD issues in their respective assignments"

- A CEO at a consultancy company [1]

Regardless of the type of organization, several companies speak of an unclear ownership of the SD issues. Who the utter most responsible person is seems to be unclear to many; either the central SD function owns the issues or they only support the rest of the employees who are responsible for their share. Companies with a responsible core function indicated they do not always have complete control of the SD work conducted in the company. Other companies with a more decentralized responsibility and a SD support function speak of employees disregarding the SD issues giving the SD group the sole ownership of the issues.

" – We have more work to do regarding middle management, to get them more involved in this, to get them to own the issues"

- A sustainability manager at a manufacturing company [25]

Even though the work is organized in different ways in the different companies, the SD functions still enjoys great support from their respective management. All companies say they have superiors or board of managers that agree with and support their work. Several companies report SD work as being a strategic issue which has been set out by the general management, meaning that they have good support for the work.

" – Sustainable development is one of our four main corporate goals. That means it becomes more important."

- A sustainability project manager at a retail company [31]

One interviewee commented that the number of employees dedicated to environmental or SD assignments have increased during the last couple of years. The interviewee also speculated that this trend will continue.

" – It has changed a lot during the last couple of years, from me being the only person trying to push the agenda, to today where we have a person in the market division that is responsible for environmental offers. /…/ If you think that it continues as today, then there will be more people working with projects that have a more clear environmental profile."

- An environmental manager at a manufacturing company [27]

10.2 Responsibility of education and the need of generalist or specialist engineers in sustainable development

The second category deals with the responsibility of education. The category discusses whether companies should supply their employees with internal education within the field of SD, or if the universities should provide the education, and the demand for, what the authors define as generalist and specialist engineers,

within the field of SD. The fist subcategory discusses internal education, whether companies ensure adequate knowledge amongst their employees and if it would be beneficial for companies if this process was provided by the universities. The second subcategory discusses whether generalist or specialist competence is demanded for within the field. The authors define a generalist engineer as an engineer who has a specialty in an engineering field but has additionally taken a mandatory course in environment and sustainable development, and a specialist engineer as an engineer who has a specialty in a sustainable development field.

Eight interviewed companies state they have, or are working on creating, internal education discussing SD. Additionally, six of the companies already have or are working on a mandatory course for all employees. Internal education mostly consists of e-learning courses or a half to a one day course. The companies utilizing the e-learning concept (four companies) have made, or will make, it mandatory for all employees to take the course. At present the companies providing regular courses only engage key personnel. These people should then, in turn, educate their co-workers.

> *" – We often create our own educational programs. We have created our own environmental course and within that, sustainable development is regarded as an elaboration of the topic. /…/ The education is general, but aims mainly at our environmental contact people, purchasers, designers and our salespeople."*
>
> - A sustainability manager at a manufacturing company [30]

Reasons for conducting internal education are several. One reason is to create a common awareness platform amongst the employees and to raise an interest in the issues.

> *" – We conducted a sustainable development course for almost all employees /…/ in order for us to get a common awareness platform around the issue."*
>
> - A sustainability manager at a manufacturing company [25]

> *" – If you have a personal interest, and knowledge in how you can influence, then you will be able to ask the right questions. I think it is more important to have knowledge in how you can influence by looking, asking and being interested, rather than having a specific technical competence."*
>
> - A sustainability manager at a manufacturing company [24]

> *" – The work within sustainable development will be expanded with an internal education for sustainable development to increase the basic understanding."*
>
> - A vice president for environmental affairs at a manufacturing company [23]

> *" – We are working on an internal education for sustainable development for the entire company. /…/ It will provide understanding of the topic and raise awareness."*
>
> - A sustainability director at a manufacturing company [22]

> *" – It is a question about awareness and understanding that everyone have the possibility to do something…"*
>
> - A CEO at a consultancy company [1]

Another reason for companies to conduct their own courses in SD is to convey their own company view of SD to their employees.

> *" – The most important issue we focus on is to get the mindset out to our employees, especially to those that are working with purchasing. /…/ our internal education focuses on conveying our values."*
>
> - A sustainability project manager at a retail company [31]

Regarding the matter of what institutions are responsible for educating engineers in SD, most companies (14 out of 16) say that the university has the overall responsibility for ensuring that the engineers receive the education demanded for. The interviewees believe that education for SD should permeate the entire engineering education, by incorporating sustainable thinking in existing courses and programs.

> *" – Sustainable development should be a core competence in engineering education, that is self-evident! /…/ though, it should be a natural part of the education."*
>
> - A sustainability manager at a manufacturing company [30]

> *" – That is what we are pushing for! Integrated in every course element. It might be done today, but it is not evident amongst our employees."*
>
> - A sustainability director at a consultancy company [2]

> *" – It is important that engineers get a basic education in sustainable thinking, and that they understand the material and energy cycles we are a part of, and that it is not a linear path. This way of thinking should be taught by the universities in a higher degree to all engineers, not just those who are going to work directly with sustainable development, if we want to create a change in society."*
>
> - A manager for business area environment at a consultancy company [4]

> *" – You have to have an understanding for what is happening all around you, therefore understanding systems and the importance of sustainable development must accompany the education. It cannot be a separate education for these issues because sustainable development is not a small blue box out there somewhere, it is all encompassing."*
>
> - A CEO at a consultancy company [1]

> *" – The more sustainable development thinking you get during your education, the better. It is just like integrating it into your business. I did not receive that in my education. We were just told: `Here is your three credit environmental course´. I thought it was the wrong way of doing it. I think it would have been beneficial to incorporate it with the rest of the education."*
>
> - A sustainability project manager at a retail company [31]

The interviewees stated that there is a need for both generalist and specialist competence in SD. However it seems more vital for the majority to provide all engineers with a good, basic understanding of SD, than employing specialists in SD. It is the engineering competence that is the key to success, and an engineer should be a specialist in an engineering field, and apply sustainable thinking to their work.

> *" – You cannot solve all problems with calculus, it does not work that way. If the engineers do not understand this then it is up to the companies to make them understand that we live in a complex society where we need broad competences, and that it is not enough to know calculus."*
>
> - A CEO at a consultancy company [1]

> *" – We need engineers to be engineers, but we also need them to be engineers that can do things in a sustainable way, a green way, an ethical way and a safe way. /…/ If they are not educated about how to do this, then they would be educated for the past, not the future."*
>
> - A senior vice president at a consultancy/ construction company [5]

> *" – You have to have a basic understanding of sustainable development when you are finished with your engineering studies."*
>
> - A head of environmental affairs at a manufacturing company [28]

" – Competence in sustainable development will be demanded for more and more /…/ You do not have to be an expert, but you should know what it is all about."

- A sustainability manager at a manufacturing company [25]

In addition to the basic understanding amongst all employees, five companies also want specialist competence in SD. They either need it right now or in the near future due to a growing demand for the competence.

" – We will need more people with key competences that can take an overall systems perspective of the environmental area, but also people with more specific competences within different areas of sustainable development. And not to forget, engineers that have both…"

- An environmental manager at a manufacturing company [27]

" – We need a higher competence level overall. More general competence would be beneficial, but we need higher specialist competence as well."

- A manager for sustainable development at a manufacturing company [20]

" – Both general and specialist competence is lacking amongst the employees over at product development. /…/ Their competence must be increased."

- A head of environmental affairs at a manufacturing company [28]

" – There is just a few people that need deeper knowledge in environmental issues, but a lot of people should know the basics."

- A sustainability team leader at a manufacturing company [21]

" – Experts that are working on this, they are not that many /…/ what is needed is an understanding everywhere and how you integrate it in what you are doing."

- A sustainability manager at a manufacturing company [25]

" – We might need 10 specialists within sustainable development in our organization, it is a pure niche market. What we also need is hundreds of engineers that have a generalist competence in sustainable development. It is the engineering competence that is the most important aspect of the engineer."

- A strategic manager at an energy company [6]

" – We are trying to make sure that all employees have a general understanding of sustainable development, but we also have specialists within the field, so we do need both general and specialist competence."

- A sustainability project manager at a retail company [31]

Some companies also estimate competence in SD as a competence which may give a student a competitive edge. However none of the interviewees working with HR speak of SD as a knowledge base taken into consideration when recruiting.

" – An engineer that already have good basic knowledge in environmental issues will have an advantage when starting to work here."

- An environmental manager at a manufacturing company [27]

" – Competence in sustainable development will be demanded for more and more. I am convinced it is an competitive edge."

- A sustainability manager at a manufacturing company [25]

10.3 Company timeframe and business goals on sustainable development

The third category discusses the interviewed companies' timeframe and business goals regarding SD issues. Due to its nature SD issues can preferably be regarded in a long term perspective, 10 – 50 years, while a short term perspective is more common for business goals, 1-10 years. What timeframes a company decides to work with may hence depict how it regards and works with SD issues.

6 out of 16 companies have short term goals that fall within the range of 1-10 years whereas the remaining 7 companies have long term goals, 10-50 years, as a complement to the short term goals for their business. One sustainability manager and a vice president for environmental affairs, working at different manufacturing company, motivates the additional long term timeframes with a present need to know what the market will look like in the future;

> *" – It is important to use both timeframes. /…/ [short term] is important because if you only look forward nothing happens /…/ and we need to start today if we want to be somewhere in 20 years. What we have not had before are the long term perspectives that we absolutely need, in order to look for directions"*
>
> - A sustainability manager at a manufacturing company [25]

> *" – Sustainable development must be seen from a societal perspective, how consumers will look like in 2020, 2030 and so on"*
>
> - A vice president for environmental affairs at a manufacturing company [23]

Two companies also refer to two additional types of timeframes. The CEO of a consultancy company [1] mentions that they create solutions for a sustainable society, for which there are no timeframes, and another interviewee, a senior vice president for a consultancy/construction company states;

> *" – There is no technical, political or economic reason for not doing [sustainable solutions] /…/ we do not need goals for 2020 or 2050, that is just delaying. Just get on with it now"*
>
> - A senior vice president at a consultancy / construction company [5]

Two other interviewees, a sustainability project manager and a business area manager at different companies, point out that quality brings long term perspectives and create a foundation for a business model with SD incorporated;

> *" – we believe that more durable and more qualitative products are good for sustainable development. In that sense the quality [department] and social and environment [department] shares agendas"*
>
> - A sustainability project manager at a retail company [31]

> *" – [long-sightedness] is a business model"*
>
> - A business area manager at a consultancy company [3]

10.4 Business reasons for working with sustainable development and how companies work with the issues

The fourth category regards the underlying reasons to why companies engaging in SD issues today. During the interviews, different clusters of reasons for working with SD arose. Except from the strategic cluster which the majority of the companies mentioned, the other clusters described below were more or less mentioned equal amount of times amongst the interviewees.

The most common cluster of reasons for working with SD amongst the interviewed companies was of a strategic nature. Business strategy, business development, product and service portfolio and order qualifier were reasons clearly stated amongst the majority of the interviewees.

> *" – There is no doubt that this is one of our most important strategic concerns"*
>
> - An environmental manager at a manufacturing company [27]

> *" – Our task is not to save the world but to expand our business, and if we do that with the wonderful side effect of receiving a world we can live in and make even more business in"*
>
> - A sustainability director at a consultancy company [2]

Profitability and cost reductions were the second most common reasons mentioned. Risk prevention and risk management as well as brand strengthening and reputation building were also motives to engage in SD.

> *" – it is important to integrate this work in the entire process to evaluate the non-financial risks connected to environment"*
>
> - A sustainability manager at a manufacturing company [30]

Other driving forces were quality management, marketing, meeting consumer demand and maintaining good stakeholder relations.

> *" – if we cannot portray our products as sustainable then no one will buy them. It is that simple."*
>
> - A research engineer at an energy company [8]

> *" – Customers demand more sustainable development. Customers, analysts, media and employees, our greatest stakeholders, possess a greater awareness today, and they want to know what [companies] do and how it affects others."*
>
> - A sustainability director at a manufacturing company [22]

> *" – There are many businesslike motives for working with this concept, and it is connected to all stakeholders such as shareholders, employees, customers and investors"*
>
> - A sustainability director at a consultancy company [2]

10.5 Company communication and understanding sustainable development

The authors believe that basic understanding of SD and system perspective thinking constitutes a good foundation for when working with SD issues. The authors therefore wanted to get an insight in the level of basic understanding for SD amongst engineers. An attempt was made to investigating if system perspective thinking is practiced, how well communication regarding SD issues works, if SD is in general viewed as tangible or intangible, and if the employees know how their work relate to SD.

11 interviewed companies clearly state that a system perspective is important amongst engineers. 7 out of the 11 acknowledge a lack of system perspective thinking amongst the employees.

> *" – Systems perspective is important. Engineers are good at delimiting, even though everything is integrated. To include everything when approaching problems, and to see totality /…/ there are no isolated problems /…/ you have to think transboundary"*
>
> - A sustainability director at a manufacturing company [22]

Regarding company communication on SD, interviewee opinions differ. Five interviewees stated that the internal communication on SD was received and understood in a satisfactory manner. A manager for

project area sustainable production [26] and a sustainability manager [24], at different companies, independently told of personal interest amongst employees facilitating communication.

> *" – there is a large interest for environmental issues and hence it is easy to communicate"*
>
> - A manager for project area sustainable production at a manufacturing company [26]

However, seven interviewees told of communication problems. Two companies talk about a need to make internal communication messages more easily understood by using the right and simpler words and a third tell of difficulties, amongst employees, of understanding the subtle connections between environmental issues and work tasks.

> *" – [the communication] must be made more simple for everyone to understand"*
>
> - A vice president for environmental affairs at a manufacturing company [23]

> *" – You have to use the right words, and then people understand what we talk about"*
>
> - A manager for business area environment at a consultancy company [4]

> *" – Environmental issues are somewhat difficult, difficult to see the connection, a more subtle connection /…/ we conducted an education in sustainable development for a large part of the corporate group with the intention of raising the issues. In order to achieve a common awareness platform, to make people somewhat educated in the issues"*
>
> - A sustainability manager at a manufacturing company [25]

Regarding the understanding of the impacts on SD from own work tasks, the majority of the interviewees speak of different levels of understanding in different places amongst the employees. Two companies educate their employees in order for them to become aware of the connections. One sustainability manager at a manufacturing company [25] mentions that SD issues would be easier to grasp if they were viewed from a business point of view instead of an environmental. Another manager for sustainable development [20] stated that the acceptance for SD issues exists but not the basic understanding.

10.6 Company outlook on future sustainable development issues

What companies believe to happen in the near five to ten years may depict a shift in importance of SD for companies, either positive or negative. Due to the variety of branches, the companies' answers mostly differ regarding what areas they expect to focus on in the future, but there are also similarities.

Two company visions that do coincide are both from companies in the consultant business. One company strives for leading a society in transition with focus on sustainable development and another strive for a sustainable society.

A manufacturing company interviewee [25] believes that higher demands will be put on produced goods by legislation, while another manufacturing company interviewee [21] states that the environmental questions will gain importance in the future.

Three companies, a manufacturing, a consultancy/construction and a retail company believe that resource use will gain importance in the future:

> *" – Resource use will become an important issue, same with use of chemicals"*
>
> - A vice president for environmental affairs at a manufacturing company [23]

> *" – waste, hazardous materials, unsustainable materials, water, energy"*
>
> - A senior vice president at a consultancy / construction company [5]

" – fuel, energy, forestry, raw materials"

- A sustainability project manager at a retail company [31]

An environmental manager at a manufacturing company does not believe their SD work will grow over time, but rather become more integrated into the organization:

" – What we see now, what we focus on, that will not decrease but rather increase. Globalization occurs and /…/ through that perspective we will gain an enhanced engagement in these types of questions. You will not speak of environmental and sustainable development issues as we do today but it will be an integrated part of our business, a natural part /…/ [it] will not grow but it will become a more integrated issue."

- A sustainability manager at a manufacturing company [30]

The above vision is somewhat coherent to a sustainability project manager's view about the future at a retail company:

" – the issues will be the same but the importance and challenges will be different"

- A sustainability project manager at a retail company [31]

A head of environmental affairs at a manufacturing company speaks of a new way of looking at business in the future, turning way from products and becoming more service oriented:

" – Companies should shift focus from delivering products to delivering services"

- A head of environmental affairs at a manufacturing company [28]

10.7 Concepts, tools and methods for sustainable development utilized by the companies

Expressed concepts, related to sustainable practice, and methodologies that have been discussed during the interviews may shed some light on what types of tools and methods the companies use. Expressed concepts have been drawn out from the interviews, however the reader should bear in mind that there is always a possibility that not all tools and methods used by a company were mentioned during the interviews. Nonetheless, it may give a picture of what types of tools the companies value the most.

The concepts, tools and methods, derived from the interviews when the interviewees were talking about what methods their respective company utilizes, can be categorized into the categories uncovered by the inventory, presented in section 6.1. The concepts, tools and methods are presented in their relative category in Table 15. The companies work with the concepts, tools and methods that are related to the SD issues inflicting on their business.

" – Politics and policies is important, since it governs the way we work. All our projects are measured against the policies…"

- A CEO at a consultancy company [1]

" – We are not looking so much to water pollution, but to water conservation because the world is running out of water."

- A senior vice president at a consultancy/ construction company [5]

" – Where I was working earlier, we had something called Life Cycle Thinking in product development. Though, I could never understand why it was supposed to be a special niche, you have to think like that in all product development."

- A manager for business area environment at a consultancy company [4]

Table 15: List of different expressed words relating to sustainable practice, and tools and methods for working with sustainable development at the companies uncovered during the interviews.

Category	Concepts, tools and methods
Assessment tools	Life cycle thinking/ cyclic flows, life cycle assessment, life cycle costing, product stewardship, design for environment, risk management, bio-mimicry, dematerialization/ transmaterialization, energy mapping and energy consultation, cost benefit analysis. Strategic Environmental Assessment
Communication	Sustainability communication
Economic aspects	Economics, economic expressions, and environmental economics
Environment	Energy, water pollution and conservation, climate, ecosystems, environmental impact, and REACH
Management	Supply chain management, and project manager qualities
Politics and policies	Politics, policies, laws and regulations, and EU standards
Resources	Resource problems, sourcing, resource efficiency, and waste management
Social impacts	Social impacts, corporate citizenship, ISO 26000
Stakeholders	Stakeholders/ stakeholder analysis
Values	Ethics and responsibilities, cultural differences, and life style and behavioral change, sustainable consumption

Some of the interviewees speak of specific assessment tools needed for their industry, while others talk about general concepts that they employ. A senior vice president of a consultancy /construction [5] company talks about the importance of Life Cycle Assessment and Life Cycle Costing, while three SD managers at three different manufacturing companies [20, 25] talk about the importance of understanding the companies stakeholders. Also, a manger for SD at a manufacturing company [25] talks of the importance of understanding cultural differences when working with SD issues. To an energy company Cost Benefit Analysis is important for doing calculations on environmental impacts, according to a senior research engineer [16].

> *" – Assessment tools are going to be very important, the whole life cycle concept, LCC, LCA, is going to be critical, especially to buildings. /…/ If you do life cycle, everything comes nicely into balance and you can justify all of this. /…/ So, sophistication in LCA and LCC is going to be key to [sustainable business]."*
>
> - A senior vice president at a consultancy/ construction company [5]

> *" – It is also very important to know who our stakeholders are /.../ understanding that the end-consumers are our stakeholders, even though they are several steps further down the product chain from where we operate."*
>
> - A manager for sustainable development at a manufacturing company [20]

> *" – It is important to understand cultural differences, that it is not always about right and wrong, and to understand different view-points. We Swedes are probably quite un-flexible when it comes to that…"*
>
> - A sustainability manager at a manufacturing company [25]

> *" – Cost benefit analysis is important to us, we are studying how to value ecosystems and biodiversity."*
>
> – A senior research engineer at an energy company [16]

10.8 Focus group discussion results

The participants of the focus group discussion were all asked to discuss the following overall questions amongst themselves, for the full-length discussion guide see Appendix G:

- What topics will the society focus on, within sustainable development, in the future?
- Will there be a greater or lesser focus on any of the three aspects, social, environmental and economic?
- Companies answers to societal needs. Should companies also try to make their imminent society more sustainable?
- Universities have the ability to influence what knowledge and competences that enters the market. Should universities take upon this role?
- What, if any, are the responsibilities of engineers today regarding sustainable development?
- Are technical solutions drivers or tools for sustainable development?

The following paragraphs are short summaries of the different topics discussed by the focus group and the comments made by the other interviewed actors.

Environmental issues will probably not stay an isolated matter in the future but be more closely connected to social and economic aspects. Today a large focus is put on climate and energy and even though these issues may grow focus will probably shift more towards resource use in the future. Another possibility is that environmental issues will grow to encompass much more than today.

Regarding climate change, there are two possible future scenarios; one where the world reach the two degree target recommended by IPCC and one where it does not. The latter scenario may result in unknown side-effects hence we might have to cope with other aspects than those of today in the future. All sustainable development issues that concern our survival may grow, and it may become even more important to optimize societal actions from a sustainable development point of view and not only environmental, social or economical viewpoints.

Another thought is that societies will let go of the social aspects if the climate change goes out of our control. Then it might come down to prioritizing the protection of national borders in order to protect the survival of nations and its people. In such a scenario the social aspects of sustainable development may be focusing on the existing national and regional society and rather than thinking globally or of future generations. There may be costs involved with isolation from the global arena for protective reasons and those who can think globally and act together regarding social aspects may gain the most or lose the least. Parallels can be made to the words current notions on terrorism, and how nations and people are more careful and prepared for what the future may bring.

Overall, engineers need to become better at communicating their knowledge and competences in the future. Today industries have difficulties with diffusing their SD technologies, processes or products on the market because competences in how to diffuse and how to market the innovations are unsatisfactory. Technical solutions should be one of many tools for society to use in order to strive and work for SD. However, technical solutions are not, by themselves, drivers for SD. Today's business models need to consider long term effects rather than short term effects regarding SD investments and pay back times. Companies need to understand such a transformation before the society at large can. There is also a societal lack of competence in being able to demand for what is actually needed, hence educational institutions and companies may have to push knowledge and innovations out on the market. Therefore,

engineers must also become better at communicating the benefits offered by using innovations beneficial for SD, and what pay backs that are involved. Education in how to communicate ones knowledge is very important and today's graduated students are lacking this competence. If you cannot communicate your knowledge it is no longer useful.

In the future, companies should work closer together in order to create synergies. Both synergies for the consumers, meeting different demands at the same time, and synergies for the producers by reducing for example resource uses can be attained. The future trend may also be that not only end-consumer products are adapted to SD but entire value chains. There is an increasing trend today regarding engaging more and more value chains and authorities in understanding and working for SD. SD work may come from within industries but it also needs to be demanded for by the society. Both upstream and downstream demand in the value chain is needed, but upstream is probably a stronger driving force.

There are different stages of how far companies have developed their engagement in SD. The last step includes SD integrated in company values, visions, goals and strategies. If SD is not incorporate throughout a company, but used as a separate issue, it is only a cosmetic usage.

CSR questions are relatively young within companies today and the concept can most probably be developed even further. The concept also needs to be adapted to the society it is exercised in, rather than existing as a copied concept from other societies.

It is possible that SD is a class issue today, and some but not all parts of the Swedish society believe SD issues to be important. It is not necessarily connected to income, but probably connected to the level of education.

Integrating SD across all educational programs should be valued higher than giving a separate course in SD. It is a much more efficient way of raising awareness amongst students and if integrated it does not have to be exchanged for other knowledge taught today. It is also important that SD is taught by giving relevant examples in a relevant context. It is important to give all engineers good SD framework to relate to. Universities should however not design their educational programs on their own but integrate other actors such as society and industry representatives in the design process. It is very important to match competence demand with supply. What is asked for are students with competence in their own educational background but who are also able to view everything from a SD perspective.

Universities have an important role to play since they educate future decision-makers and do therefore hold the responsibility to align education in SD directions. University education in SD cannot be the only driver for a societal change and a transition must be driven though many parallel channels at the same time. Nonetheless, universities play a large role. The outer most responsibility lies within the government deciding on laws and regulations. Companies have the possibilities of becoming a large driving force for achieving SD however authorities and consumer demand will most probably be the strongest driver generating a change.

11 Quality of the interviews and the focus group discussion

This section discusses the quality of the interviews and focus group discussion regarding methods, interviewers and interviewees respectively.

A future reproduction of the research is possible since all methods used are comprehensively described. However since the interviewees are kept anonymous and the recordings made are destroyed the authors cannot guarantee that the same results are obtained during a reproduction.

The analysis stages of labeling, categorizing and looking for trends have initially been made parallel by the two authors, and later compared, to ensure equal views and ideas. The results compiled from the interviews were reviewed by three impartial people, the opponent to the master thesis and two employees at Chalmers Centre for Language and Communication. This enhances the quality of the research.

The interviews have mostly been held by one author at a time however both authors have acted as interviewers. This may have affected how the interviewees have interpreted the interview questions, though this seems unlikely since all questions were thoroughly discussed amongst the authors on beforehand and both authors were present at all interviews.

The authors are of the opinion that all interviewees answered truthfully. Nevertheless, none of the authors have a great experience in creating interview templates or conducting interviews which may have affected the results. It is also possible that the authors, without their knowledge, did not succeed in remaining objective while interviewing.

As an interviewer it is difficult to remain objective throughout the entire process and to not be influenced by the material collected in previous interviews. It is easy to draw premature conclusions while collecting data since humans have a tendency to see and hear statements corresponding to the purpose of the study or own opinions (Wibeck, 2000). This is a weakness of the collected data from the interviews and focus group discussion and it is therefore an area the authors have kept in mind when trying to verify the results.

Another weakness of the research is the type of people targeted. By mostly interviewing those who obviously believe SD work in companies is an important issue, since it is a part of their profession, the results may be skewed. The authors' intention was initially to meet with a greater range of professions than what actually occurred. Due to time constraints and difficulties with identifying persons to interview this was not possible. Thus the authors chose between turning to those who may be overenthusiastic and meeting those who possibly new too little. Since the aim is not to generalize the results but only to depict a possible present and future need the authors believe the results, if skewed, depicts a need of the cutting edge companies in Sweden which may represent a path all companies must take in the future. The alumni survey was added to the research in order to verify or contradict the interview results and the focus group discussion in order to debate about the societal future needs hence the demands for the Swedish industry to take SD into consideration.

When being interviewed it may be difficult to stay impartial, and especially if the subject discussed is of great importance for the interviewee. Some of the areas and subjects discussed during the interviews may be more sensitive for partiality and are therefore discussed here:

- The second category discussing who bears the responsibility of educating engineers may only depict what the interviewees wish for rather than the objective truth. It is easier to say that the university is responsible for all education since the companies are then relieved from the duty and can hold educational institutions responsible for insufficient knowledge or competences amongst engineers.

- The fourth category discussing the underlying reasons to why companies engage in SD work may also be subjected to impartial opinions. When analyzing the interviews it is difficult to determine if the reasons mentioned are actual reasons acted upon by a company or the interviewees own opinions on plausible reasons but with no actual reinforcing examples.

- The fifth category, discussing understandings for SD issues may not be subjected to partiality however it may be a case of misinterpretations by the interviewees. When the interviewees' state that communication directed towards employees is not comprehended properly due to lack of knowledge, it may also be a case of disinterest amongst the employees.

- The sixth category discussing what companies believe will happen to the SD and their work over the next five to ten years may also be subjected to impartial answers. The interviewees whose work is related to SD may be overenthusiastic while the interviewees whose work do not relate to SD may be too unenthusiastic.

" – Our task is not to save the world but to expand our business, and if we do that with the wonderful side effect of receiving a world we can live in and make even more business in"

- An sustainability director at a consultancy company [2]

Part 4: SURVEYS TO VERIFY INVENTORY & INTERVIEW RESULTS

The inventory of Chalmers' education for sustainable development indicates what type of knowledge and competence is attained at Chalmers. The information was used as a basis for the company interviews in order to assess whether the different companies saw a need for the corresponding competences. Additional to the interviews the authors created a survey directed towards Chalmers' alumni aiming at examining the need of knowledge and competences in SD among engineers whose main responsibilities are within another engineering field than SD. The aim is to complement the interview results in order to depict the industry's needs in an as truthfully and unbiased way as possible within the time constraints of the research. The alumni survey was supplemented with a survey sent to the third year students at Chalmers with the aim to examine their thoughts on education in environment and sustainable development, and to verify the results from the inventory by relating the knowledge the students had attained to the courses they have studied.

12 Survey theoretical framework

A survey is a tool used to collect opinions of a larger group of people, designed with fixed questions and with predefined answering alternatives. When the questions regard subjective notions such as opinions, attitudes and emotions it is preferred to construct predefined scales as answering alternatives, such as a Likert-scale (Höst, Regnell, & Runesson, 2006).

The way the sample, the respondents, is chosen sets the standards for the possible uses of the results. The choice of survey sample is also important in order for a valid analysis to be made (Saris & Gallhofer, 2007). The aim is to choose a sample which is highly representative for the target group, thus making the results generalizable. To improve the answering frequency, a reminder can be given (Höst, Regnell, & Runesson, 2006). Another way to increase the possibility of generalizing the results from the survey is to replicate the survey questions from other surveys, to assess whether the same answers are attained from different respondents (Schuman, 2008).

The survey should be tried out on a test group before distributed to the larger target group. The aim is to identify any obscurities or defects and collect viewpoints on the framing of the questions (Höst, Regnell, & Runesson, 2006).

The survey response rate is generally considered to be the amount percentage of respondents that have responded to the survey. The response rate is also a measure of how accurate the results from the survey correspond to the general opinions of the entire survey sample. Previously, a survey with a low response rate was considered less reliable than a survey with a higher response rate, but this has been shown by Visser, Krosnick, Marquette, & Curtin (1996) not to be true. In some cases, especially concerning election polls, a survey with a low response rate might even be better than a survey with a high response rate (Visser, Krosnick, Marquette, & Curtin, 1996).

13 Survey methodology

The authors created two different surveys, one alumni and one student survey. Both surveys have been influenced by results from various sources, most prominently the results from the interviews and inventory. In order for the authors to connect the results to surveys made by Chalmers (2009a) and the Swedish Association of Graduate Engineers (Dahlberg, 2009), some questions have been replicated from the above mentioned surveys.

13.1 Survey sample

The authors conducted two surveys, the alumni survey and the student survey, where the respondents were either alumni or students from Chalmers. The alumni survey addressed 560 Chalmers alumni who all graduated in 2006. The reason for choosing graduates from 2006 was that they have been working enough amounts of years in order to understand the work tasks at their respective work, while still having a good recollection of their studies at Chalmers. The choice of the specific target group of alumni was initially created by the Market and Communication unit at Chalmers for Chalmers alumni survey in 2009. The Association of Graduate engineers' alumni survey was sent to graduates from 2005 and 2006, meaning that the survey sample in the authors' alumni survey overlapped both Chalmers alumni survey and the Association of Graduate engineers' survey to some extent. The number of alumni invited, the number of respondents and the response rate are presented in Table 16.

The student survey was sent to all third year students at Chalmers, giving the authors a sample of 2400 students all enrolled in studies at their third year at Chalmers. The choice of survey sample was made based on that all third year students have taken, or was currently studying, a course in environment and

sustainable development at the time of the survey. Consequently the survey results can be connected to the inventory results, since all respondents in the student survey have taken the mandatory course in environment and sustainable development. The number of students invited, the number of respondents and the response rate are presented in Table 16.

Table 16: Survey sample and response rate for the two surveys created by the authors.

	Invited to respond	Responded	Response rate
Authors' alumni survey	580	136	23.4 %
Authors' student survey	2440	650	26.6 %

The survey response rate for the two surveys lies between 23 and 26 %. Since it can be seen as a relatively low response rate, the authors have consulted the literature discussed in section 12 where it is stated that a survey with a low response rate might be as accurate as a survey with high response rate, or even more accurate in some cases. Still, the authors have chosen to select programs where the response rate lies above 45 % and where at least 35 respondents have answered the survey in order to get a high enough response rate, coupled with enough respondents.

13.2 Delimitations

The authors chose to not allow respondents to answer open ended questions, since they are time consuming to analyze and the research had time constraints. The authors' alumni survey was only sent to the alumni of 2006. This was a choice made in order to let the respondents completely coincide with the respondents of Chalmers alumni survey, which enabled replication of some survey questions.

The student survey results were analyzed by selecting a couple of basic rules for comparison and selection. Engineering programs with fewer than 35 respondents as well as less than 45 % respondents per program were omitted. The reason was to analyze programs with a higher response rate than for the overall survey. Educational programs were selected on the basis of the overall delimitations made in the thesis, meaning that architecture, naval and marine science and those bachelor programs only resulting in a bachelor degree were not analyzed.

The surveys only asked of perceived knowledge and competence, which was to be compared to the amount of SD issues being taught at Chalmers. The surveys do not assess the respondents' actual knowledge in SD.

14 Survey results

The results are presented in a similar manner to how the authors' alumni survey was built up. Firstly, short background information about the respondents is presented. Secondly, results relating to company specific questions are presented. Lastly the results relating to the respondents' opinions on their Chalmers education are presented. Here, the results from the authors' student survey play a large role as well. Results from other relevant surveys will be presented where prudent in order to highlight results from and to give an additional perspective to the authors' alumni and student surveys, the inventory and the interviews.

14.1 Survey results terminology

The authors have collected results from several surveys hence there is a need to clarify and to distinguish between the different surveys. The surveys from where results have been obtained are the following; Chalmers alumni survey (Chalmers, 2009a), the Association of Swedish Graduate Engineers alumni survey

(Dahlberg, 2009), and the alumni and student surveys conducted by the authors. All surveys have the same type of respondents, either Chalmers students or Chalmers alumni. A list of the different surveys is presented in Table 17.

In order to make a distinction between the results collected by the authors, and the two other surveys, a color coding scheme has been applied throughout the thesis. Bars shown in a blue tone are those collected from the *surveys created by the authors*, and bars in a red tone are those collected from *the two other surveys*.

Table 17: List of surveys presented in the results section.

Survey	Description
Chalmers alumni survey	Sent to all three- and five-year engineering alumni that graduated from Chalmers in 2006 registered in the alumni database. The survey was conducted in 2009. Half of the sample was contacted by email and half by regular mail.
Association of Graduate Engineers alumni survey	Sent to all three- and five-year engineering students that graduated from any university in Sweden in 2005 and 2006. The survey was conducted in 2009. The results used in this report are based on Chalmers graduates.
Authors' alumni survey	Sent to those in Chalmers alumni survey who were contacted by email. The survey was conducted in the spring of 2010.
Authors' student survey	Sent to all three- and five-year engineering student at Chalmers registered as studying their third year. The survey was conducted in the spring of 2010.

14.2 General respondent background questions

In the authors' alumni survey the respondents were asked a few background questions related to their profession. The background questions were based on background questions from Chalmers alumni survey, though slightly altered to correspond to the results from the interviews conducted by the authors.

14.2.1 Area of employment

The respondents were asked in what area they are working. The results are presented in Figure 15, and a clear majority of the respondents work in the private sector. The answers from the authors' and Chalmers alumni surveys correspond thus, the respondents have a similar composition in both surveys.

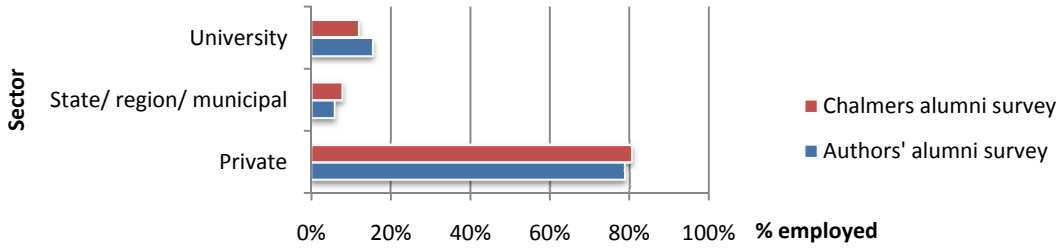


Figure 15: Area of work; private company, state or municipal work or university work. Most of the alumni are working in the private sector (Chalmers, 2009a).

The following question concerned responsibilities at the workplace. In the authors' alumni survey three more categories were added based on the interviews conducted with the companies; purchase responsibility, research and development responsibility and environmental responsibility. These three categories were added since the company interviewees mentioned purchase responsibility as an important area where SD work is conducted. The authors added R&D to differentiate from the development/

construction category and also added environmental responsibility to assess whether any of the respondents had that responsibility according to them. It is important to note that the percentage of respondents that have environmental responsibility only amounts to 2 %. The low percentage is appreciated by the authors since the aim of the survey was to reach engineers who do not primarily work with SD issues, since that type of engineers were covered in the interviews.

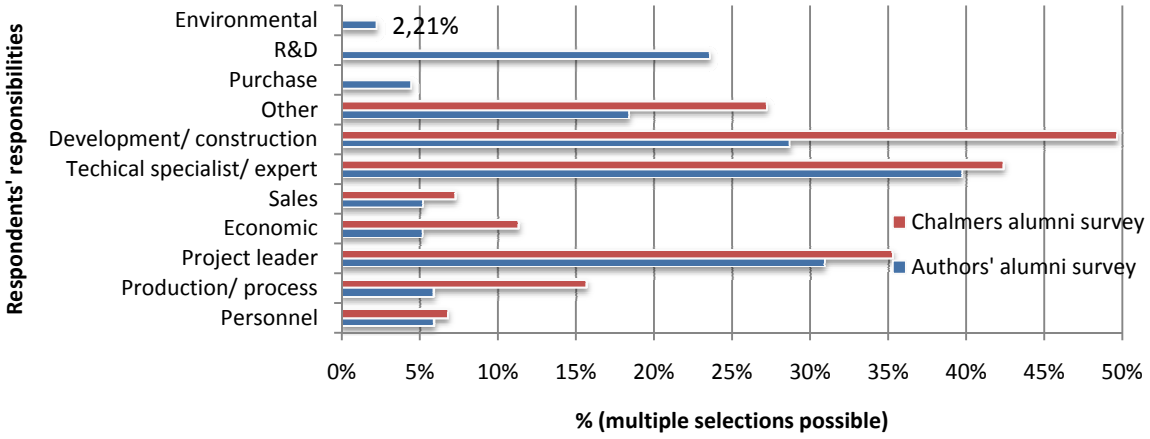


Figure 16: The respondents' responsibility at their respective workplace. The three options environmental, R&D, and purchase responsibility were only available in the authors' alumni survey (Chalmers, 2009a).

14.2.2 Respondents' understanding of sustainable development

In order to get a good picture of the respondents' background, a number of questions were asked to ascertain the respondents' knowledge and competences in sustainable development. It is important to assess whether the respondents understand the topic at hand or not. If the respondents do not understand the concept of sustainable development, it may be impossible for them to understand what knowledge and competences related to SD they lack.

To analyze whether the survey respondents have a good understanding of SD issues and why companies choose to work with them respectively, the respondents were asked to rate ten different statements on why companies choose to work with SD. Five of these were selected based on the results from the interviews, and five other were added to give alternative options. Reasons to why companies should work with SD are according to alumni primarily to strengthen company brand and reputation, to meet customer demand, and to achieve economic profitability. The top three reasons mentioned by alumni correspond to three out of the top five reasons stated in the interviews, the additional two being eliminating company risks and reduce company costs. The results can be seen in Figure 17.

The same question was posed to Chalmers students. The students rate the statements in a similar way to the alumni, see Figure 17. All of the respondents tend to focus on the business part of SD as being the reasons for a company to work with SD. The differences between the two respondent groups are negligible. The students rate strengthening company brand and reputation as the most important reasons for working with SD. The four most important reasons for working with SD according to the students are all related to the company's business development.

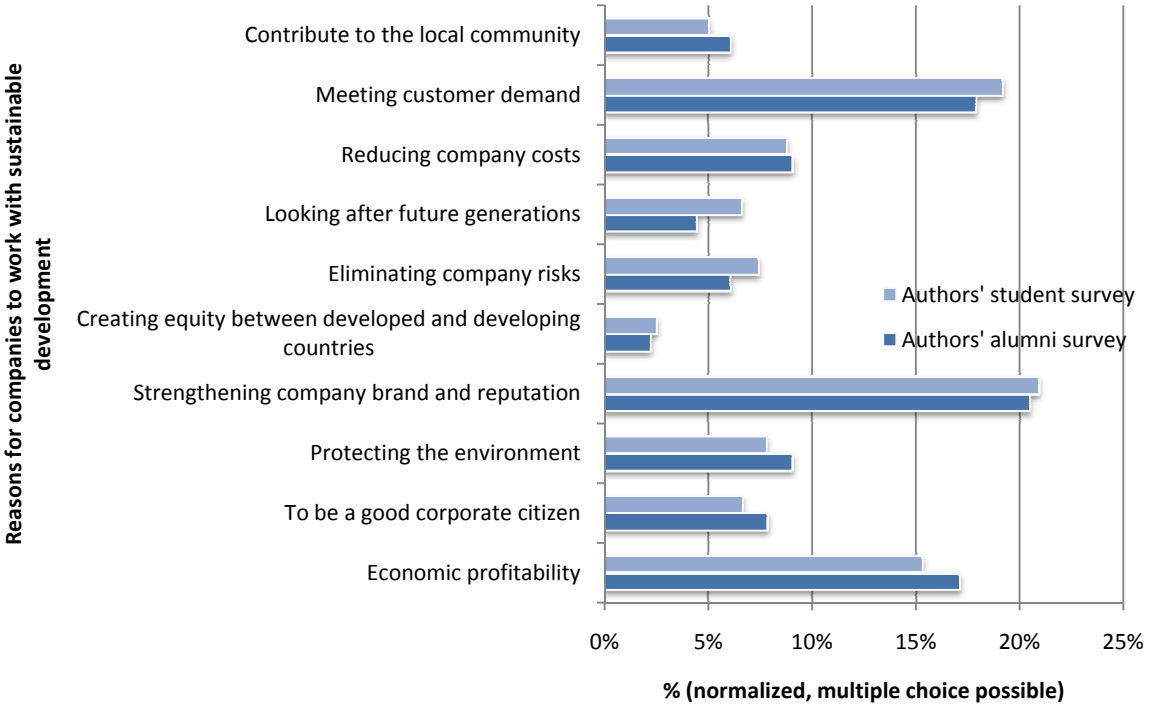


Figure 17: What are the basic driving forces that make companies work with sustainable development today?

14.3 Sustainable development at Chalmers

In order to compare the results of the surveys to the education conducted at Chalmers, a good understanding of the respondents' perception of their respective education is important. The respondents were in several questions asked to rate their perception of Chalmers' education in environment and sustainable development.

Results from both Chalmers alumni survey and the authors' alumni survey show that the respondents, according to themselves, lack formal knowledge in the subject of SD. 71 % and 65 % of the respondents in the authors and Chalmers alumni survey respectively, state they have knowledge related to 1-5 on a scale from very limited knowledge (1) to very good knowledge (10) in environment and sustainable development, see Figure 18.

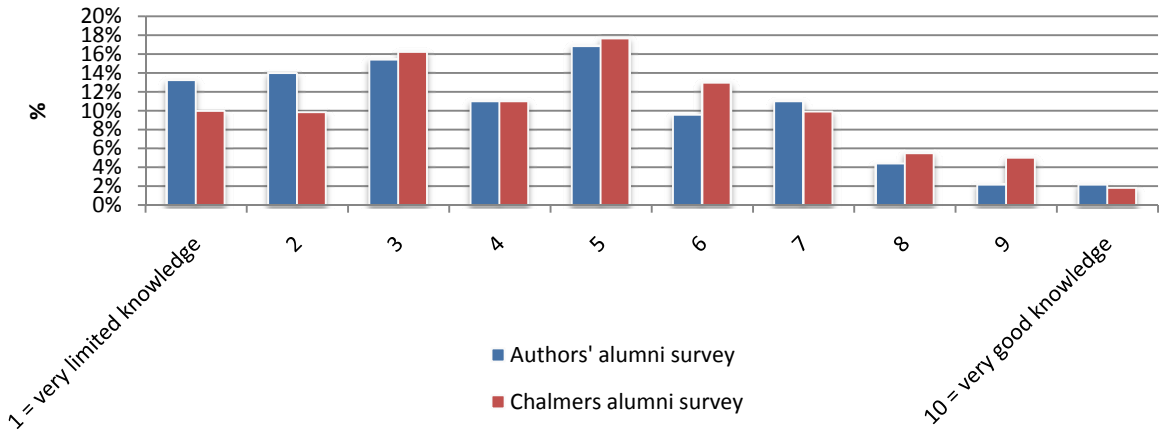


Figure 18: I think I attained knowledge within the subject sustainable development at Chalmers. Both survey sample groups answer similarly (Chalmers, 2009a).

The two surveys conducted, alumni and student, show that there is a difference between having attained formal knowledge in SD and having an insight into the concept of SD. Both the third year student at Chalmers and the Chalmers alumni were asked if they think they possess "good insights into the concept of sustainable development", see Figure 19. Almost three quarters of the students (74 %) think they have a good understanding of the concept. Half of the alumni state they think they have good insight in the concept (50 %), the other half are of the opposite opinion (48 %).

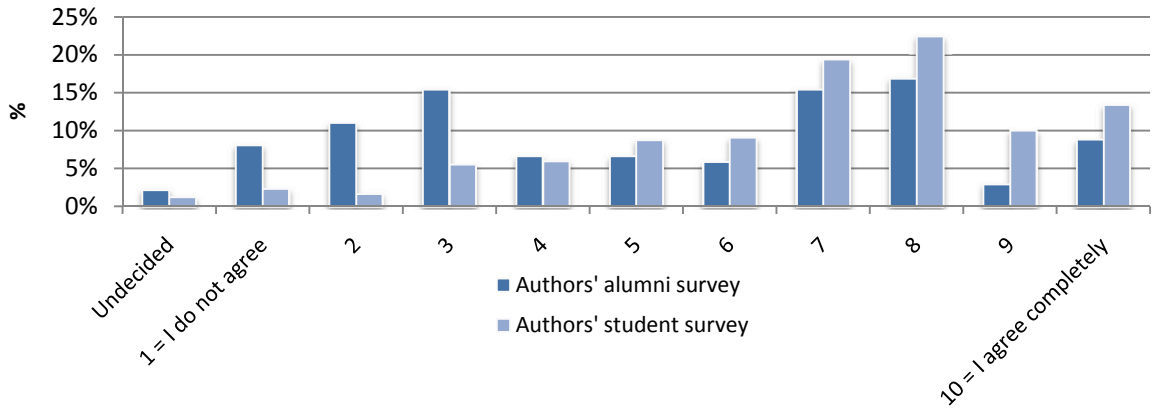


Figure 19: I think that the education at Chalmers provided me with knowledge and skills so that I have a good insight into the concept of sustainable development. In comparison, the students think they have attained greater insights into the concept, than alumni.

In Figure 19, the students' and alumni's perception of their own understanding of the concept SD is presented. In comparison the students have a higher perceived understanding of the concept, however this do not necessarily correspond to a higher actual understanding. The result either shows that alumni, who have been working for a number of years, have understood the complexity of the concept, or that they actually have less understanding of the topic.

A similar question relating to perceived knowledge was posed in the survey by the Swedish Association of Graduate Engineers, asking the alumni if their education made them enough prepared to develop products and techniques in regard to SD. This question was re-introduced in the authors' alumni survey in order to compare it to the Association for Graduate Engineers' survey results. A majority of the respondent in both surveys think their education did not prepare them enough for developing products for SD, see Figure 20. Even though the results presented in Figure 20 have different scales it is possible to compare the results from the two surveys. 58 % of the alumni in the Association for Graduate engineers' survey, and 63 % of the alumni in the authors' alumni survey answered that they were very poorly or quite poorly prepared for developing products and technology with regards to SD.

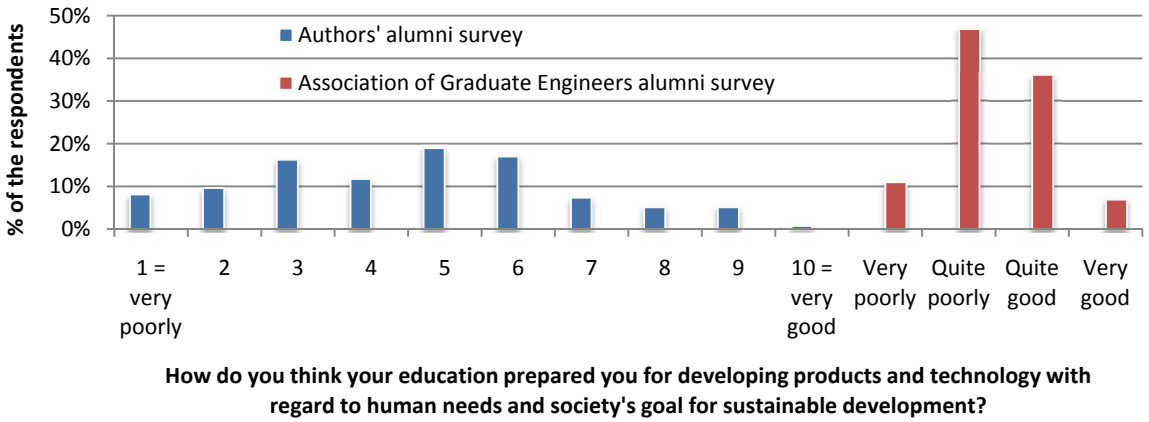


Figure 20: How did your education prepare you for developing products and techniques in regards of sustainable development? 58 % of the alumni in the Swedish Association of Graduate Engineers' survey and 63 % of the alumni in the authors' survey state they are poorly prepared (1-5, very and somewhat poorly) (Dahlberg, 2009).

To shed some light on why the alumni do or do not think they were educated enough, a question regarding the necessity of SD in the education was posed to the third year students at Chalmers by the authors. In Figure 21, it is evident that it depends on what program you study whether you feel that SD is important or not in relation to your education. Almost 85 % of all respondents regard SD as relevant for their education. Almost all of the chemical engineering students feel that SD is relevant to their education. On the contrary more than one third of the computer engineering students say that it is not relevant, or do not know whether it is relevant or not.

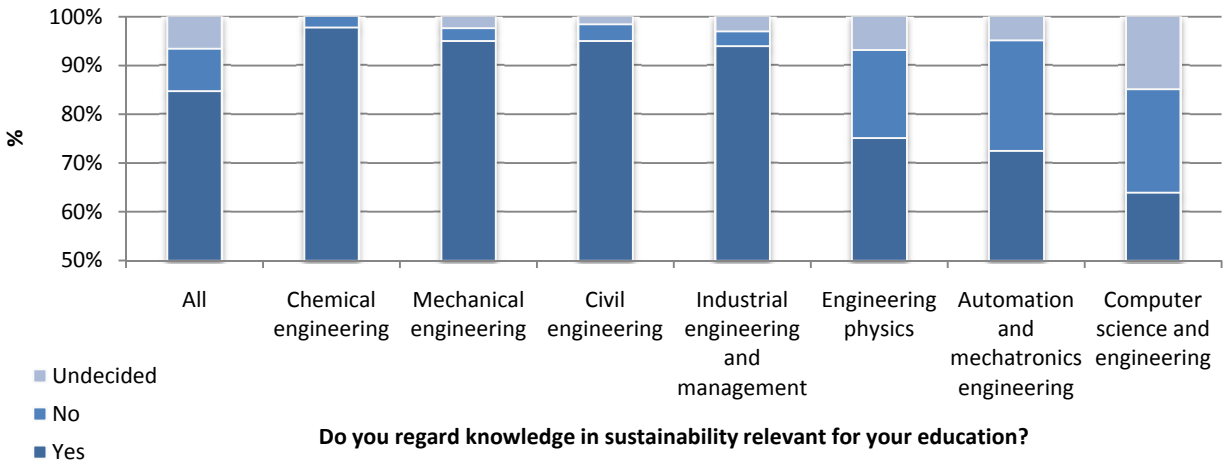


Figure 21: Do you regard knowledge in sustainable development relevant for your education? (Note that the y-axis begins at 50 %. Survey: authors' student survey).

In Figure 21, three programs are identified as having students who, in comparison, regard SD as less relevant for their education than student from the other programs; engineering physics, automation and mechatronics engineering, and computer science and engineering. The programs can be further analyzed by making comparisons to the level of integration of SD in the courses in the respective programs and if the students believe they have a good understanding of the concept.

Looking at computer science and engineering, it has a comprehensive bachelor level course in environment and sustainable development but no further integration of environment and sustainable development in the courses mandatory for the program according to the inventory, see Figure 8 and section 6.2.1. The students in the program do not regard knowledge in sustainable development as relevant for their education as other students at Chalmers however they do believe the course gave them insight in the meaning of the concept, see Figure 21 and Figure 22.

Engineering physics has a less comprehensive course in environment and sustainable development no further integration of environment and sustainable development in the courses mandatory for the program according to the inventory, see Figure 8 and section 6.2.1. And as with the previous program the students at the physics engineering program do not regard knowledge in sustainable development as relevant for their education as other students at Chalmers but on the contrary they show on less insight in the meaning of the concept, see Figure 21 and Figure 22

Automation and mechatronics engineering has one bachelor level course in environment and sustainable development, but a relatively low level of integration of environment and sustainable development in the courses mandatory for the program, see Figure 8 and section 6.2.1. The students do not regard knowledge in sustainable development as relevant for their education as the engineering physics and computer science and engineering students. Still, they do have a fairly good insight in the meaning of the concept according to themselves, see Figure 21 and Figure 22.

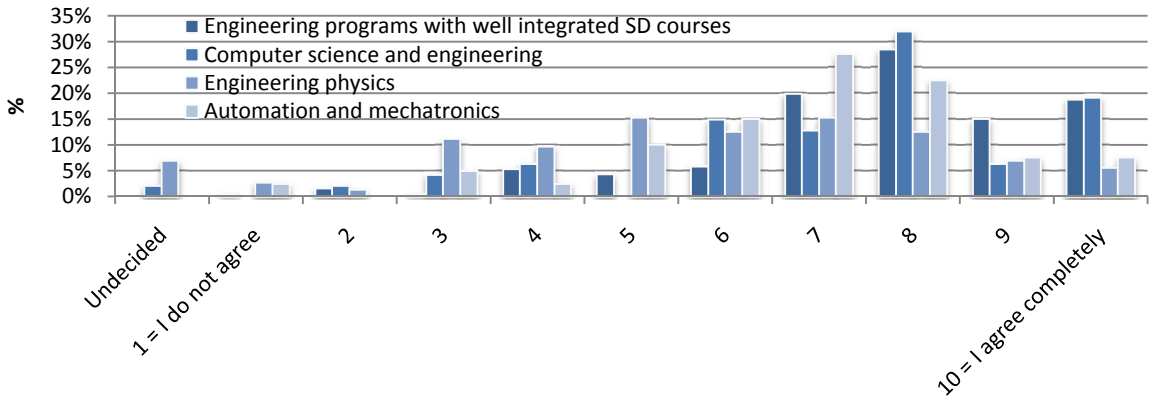


Figure 22: Insight into the concept. Computer science and engineering have a course with a large amount of sustainable development course contents. This has probably given the computer engineers a good insight into the concept. The engineering physics program has a less comprehensive course on SD and no further integration, hence the respondents have less insight into the concept. (Survey: authors' student survey)

In Figure 23, figures showing on what way the respondents in both the authors' surveys came in contact with environment and sustainable development at Chalmers are presented. Most of the respondents came in contact with environment and sustainable development either through parts of different courses, or as a basic course in the field. Four percent of the alumni studied a master program in the field.

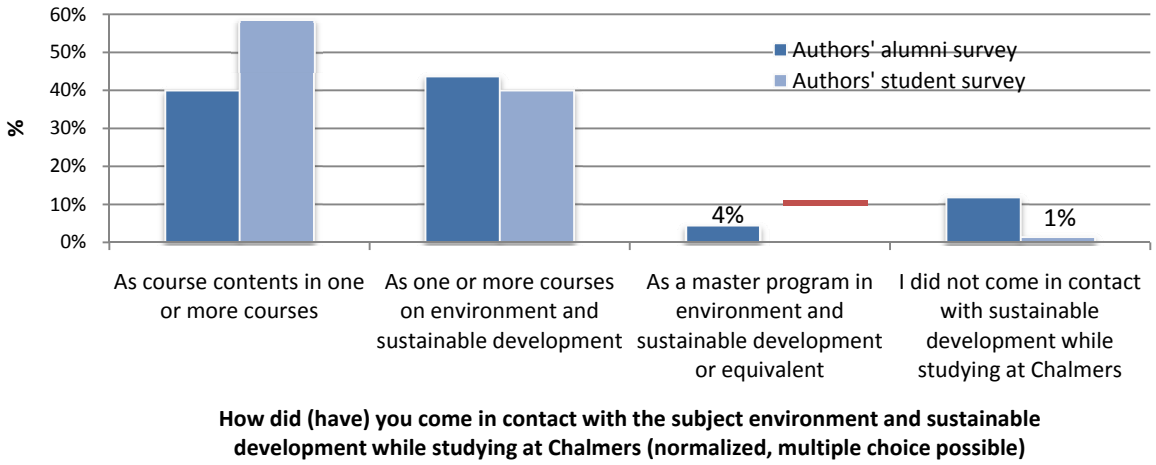


Figure 23: In what way did (have) you come in contact with environment and sustainable development during your studies at Chalmers? For comparison the amount of admitted students in sustainable development master programs in 2009 was 10 %, as shown by the red line (Chalmers, 2009d). The authors' student survey only approached third year students, hence none of the respondents could answer that they were studying a master program in SD.

Currently, at least 10 % of the students enrolled in a master program at Chalmers are pursuing a degree in any of the related SD programs (Chalmers, 2009d). As a result, 90 % of the students enrolled in a master program at Chalmers are studying a program which has taken no, or little, SD approach. Hence 90 % of students are only subjected to studies in SD through the mandatory course, or course elements, in environment and sustainable development taken during their respective bachelor studies.

14.4 Sustainable development at the workplace

In order to understand why one should study SD, one must understand why it is important in the first place. The authors also intend to assess the level of responsibility for SD issues amongst the alumni and if they believe they possess enough competence to handle this responsibility.

One way of assessing whether SD is regarded as important or not is to see if SD issues are a part of the daily work. This question was posed to the alumni through the authors' alumni survey. 35 % of the respondents say they come across SD issues in their work either daily or sometimes, see Figure 24.

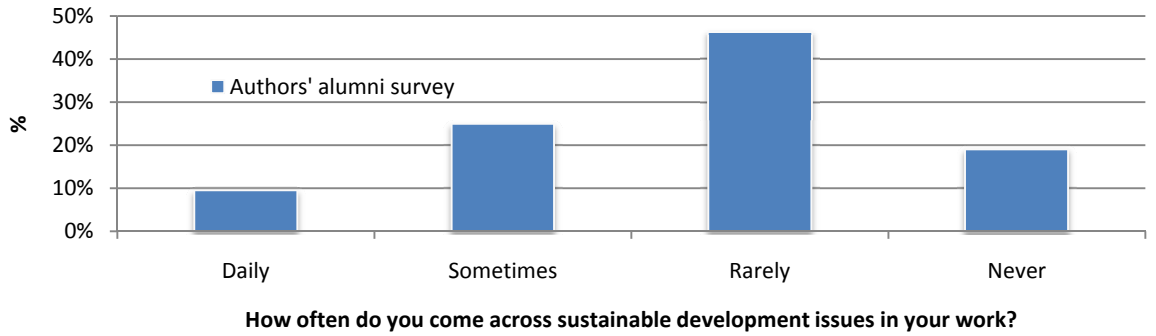


Figure 24: How often do you come across SD issues in your work?

Another interesting aspect to assess regarding SD at the workplace is the level of responsibility and consideration for SD aspects in the respondents' work. 52 % of the respondents say that they are responsible for SD aspects in their work, see Figure 25.

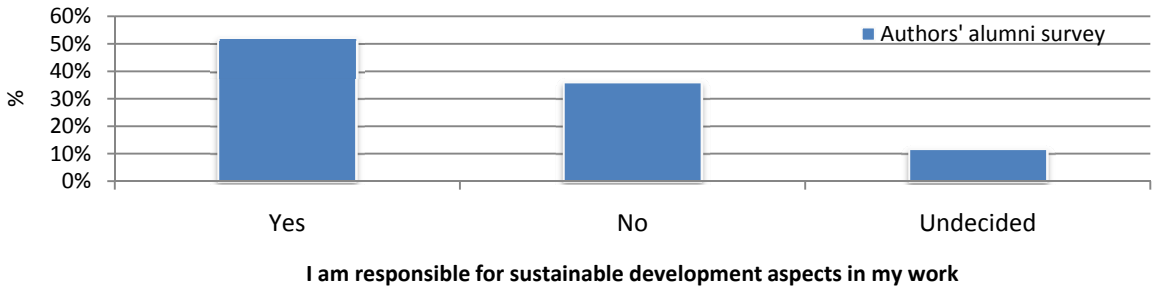


Figure 25: I am responsible for SD aspects in my work. 52 % of the respondents state they are responsible for SD aspects.

Another question regarding working with SD issues, concerns whether the respondents can relate their work to the company's SD goals. In Figure 26, 39 % of the alumni states they can relate their company´s SD goals to their work and almost as many, 37 %, say that they cannot relate their company's SD goals, the rest are undecided.

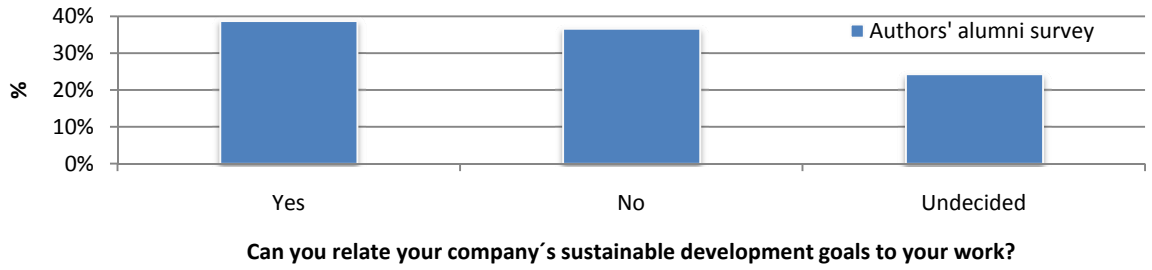


Figure 26: Can you relate your company's SD goals to your work? Most respondents cannot or do not know whether they can relate their company´s SD goals to their work.

There seem to be a correlation between relating company goals and the amount of alumni which comes across SD issues in their work. The alumni who can relate their company's SD goals to their daily work also state they come in contact with SD issues more often than the ones that cannot relate the SD goals to their daily work, see Figure 27.

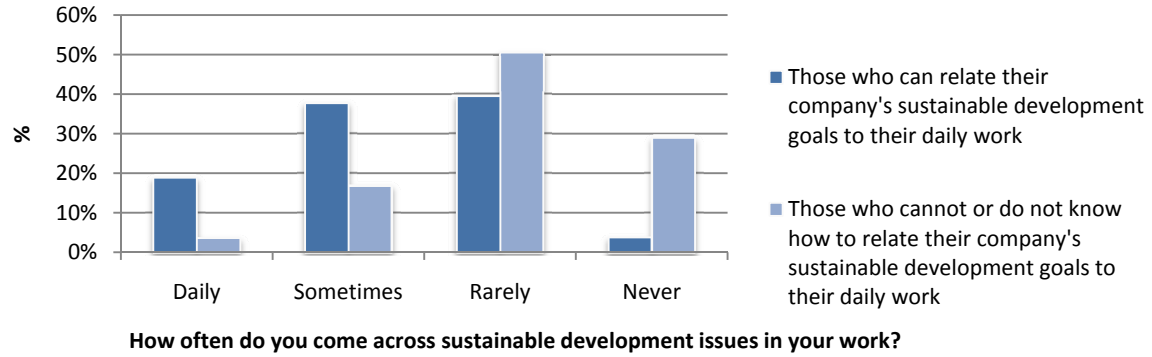


Figure 27: How often do you come across sustainable development issues in your work? Those who can relate the company goals to their work come into contact with SD issues more often than those who cannot. (Authors alumni survey)

Another aspect concerns who has the responsibility of taking SD issue into consideration, each and every employee taking responsibility for SD issues related to their own work, or another authority bearing the sole responsibility. This is also connected to the understanding of the topic, as can be seen in Figure 28,

where the alumni who can relate to the company goals are also responsible for looking after SD issues in their daily work to a greater extent than those who cannot relate the company goals to their daily work.

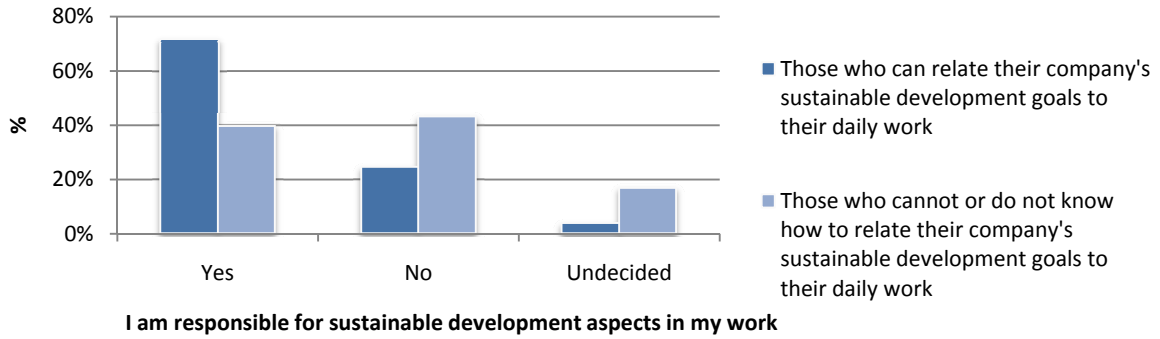


Figure 28: I am responsible for sustainable development aspects in my work. In general, those who can relate the company goals are also responsible. (Authors' alumni survey)

The results from the interviews show that several companies conduct internal education, hence questions on internal education were added in the survey. The first question dealt with the presence of internal education for sustainable development at the respondents' workplace. Only 20 % answered that there is some form of internal education in SD available at their workplace, and at the same time, 50 % think that there is a need for some form of internal education in SD at their workplace, as can be seen in Figure 29.

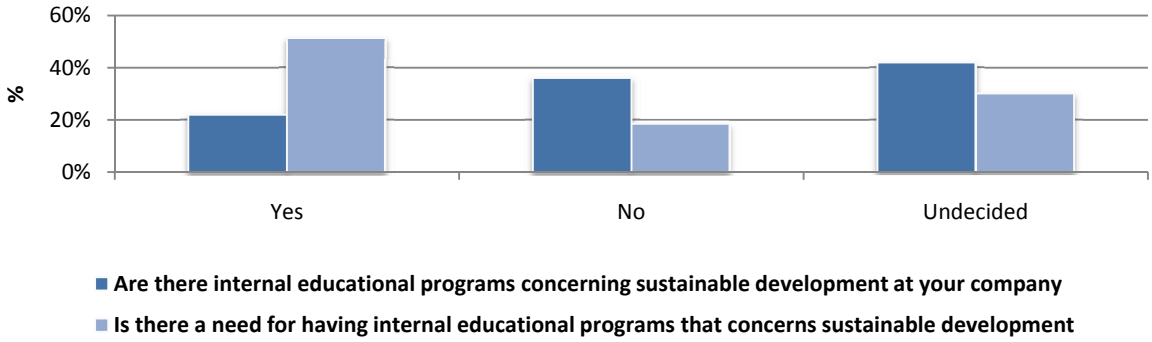


Figure 29: Are there company educations at your workplace regarding SD and is there a need for such educations? (Survey: authors alumni survey)

In Figure 29, the respondents say that there is a need for internal educations at their workplace and in Figure 25, 52 % of the respondents say they are responsible for SD aspects in their work. Since more than half of the respondents were responsible for looking after SD aspects, an important question arises; do the respondents have enough competence to look after these issues. In Figure 30, 32 % of the respondents say they have enough competence to make decisions from a SD perspective. It is also evident that some of those who are responsible for looking after SD aspects in their daily work correspond to those who lack competence, see Figure 30.

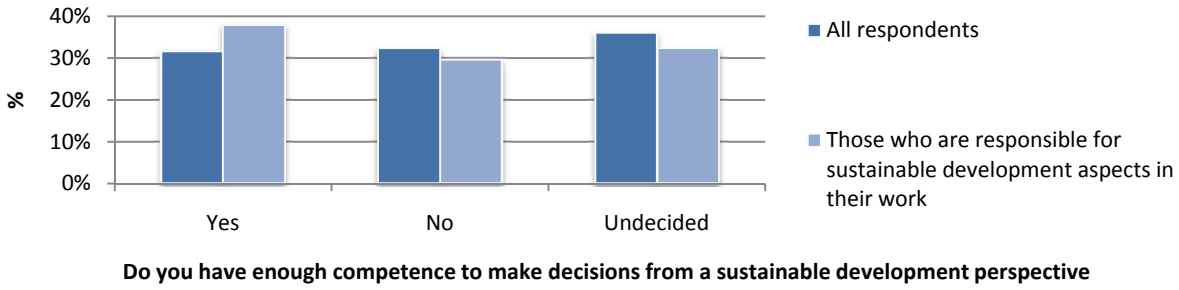


Figure 30: Only 32 % say that they have enough competence to make decisions form a SD perspective. Those who are responsible for looking after SD perspectives in their work are slightly more competent. (Survey: authors' alumni survey)

The same issue regarding having enough competence to make decisions from a SD perspective, as seen in Figure 30, can also be seen in Figure 31. Out of the alumni who come across SD issues at their work daily or sometimes, only 47 % believe they have enough competence to make decisions from a SD perspective, see Figure 31.

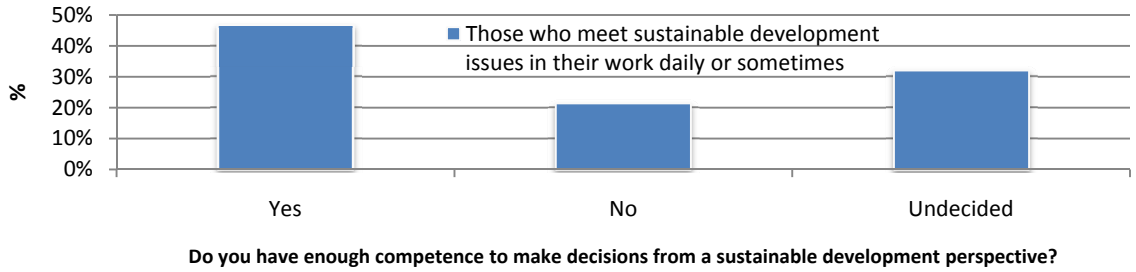


Figure 31: Those who meet SD daily or sometimes concerning whether they have enough competence to make decisions from a SD perspective. (Survey: authors' alumni survey)

More than half of the respondents are responsible for looking after SD issues in their daily work. This can be related to the fact that many of the respondents have a company management that supports work in SD, as can be seen in Figure 32. Here, 54 % claim that they have a company management that actively support work in SD.

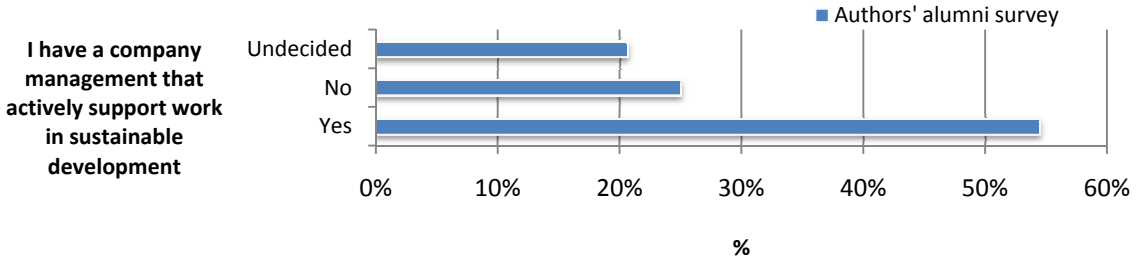


Figure 32: 54 % of the respondents has a company leadership that supports work in sustainable development. (Survey: Authors' alumni survey).

Even though 54 % of the respondents have company managements that support work in SD, not all of them are encouraged to look into SD aspects in their daily work. Only 62 % of the respondents who have a supportive management claim they are encouraged to look into SD aspects in their daily work, see Figure 33.

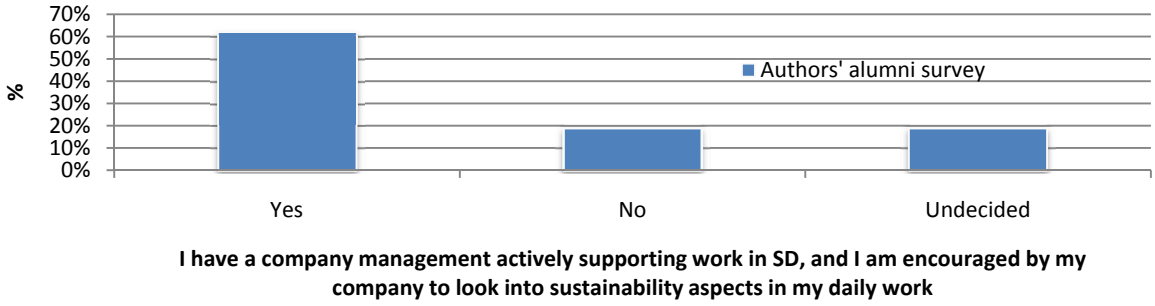


Figure 33: Even though the company management actively support work in sustainable development, only 62 % are encouraged to look into sustainable development aspects in their daily work. (Survey: Authors' alumni survey).

Regarding the respondents own competence in SD, and their ability to use that competence, the following question asked if there have been any instances when the respondents lacked sufficient competence in SD. In Figure 34, 27 % of all the respondents and 30 % of the respondents who are responsible for SD issues in their daily work, say there have been instances when they lacked competence in SD.

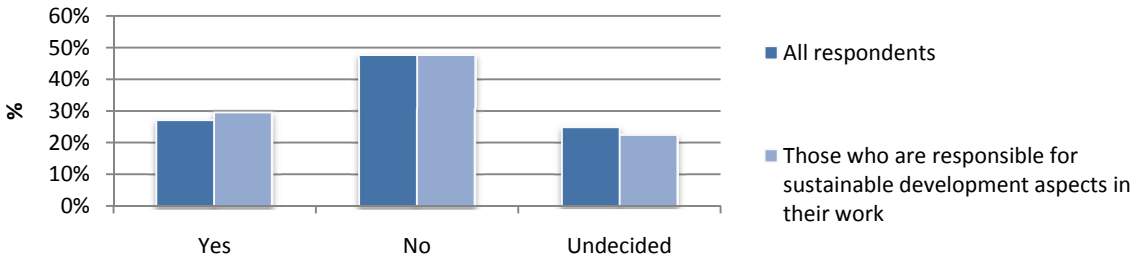


Figure 34: Have there been instances where you have lacked sufficient competence in SD? (Survey: Authors' alumni survey)

14.5 Knowledge and competence need in sustainable development

In order to connect the results to the interviews and the inventory, information about the competence needs were required. Since the respondents say they lack formal knowledge in SD, see section 14.3, it was interesting to assess what knowledge and competences the alumni think is needed in order to work with SD, and what knowledge they perceive was insufficient in their education at Chalmers. The survey question was based on the inventory and interviews to a large extent. The eleven different areas of knowledge taught at Chalmers and asked for by the interviewees were presented to the survey respondents. The respondents were then asked to first comment which competence areas they felt were insufficient in their education at Chalmers, and after, rate which areas they think are the most important when working with SD.

The knowledge areas that the respondents say were insufficient in their Chalmers education were primarily economic issues, followed by social impact, green technologies and then assessment tools, see Figure 35. When related to the inventory results, it is obvious that economic issues are the knowledge areas least covered in the environment and sustainable development courses in the bachelor programs, see Figure 9. However, it should be noted that alumni state economics as an insufficient knowledge area, regardless of it being related to SD or not. According to Chalmers' alumni survey, only 32 % of the respondent mention that their education at Chalmers gave them better than average knowledge in economics, business organization and entrepreneurship (Chalmers, 2009a).

In Figure 35, it is noticeable that the respondents think their education in environmental studies was satisfactory, but their education in economics and social studies were not. Alumni also want more information on green technology and assessment tools.

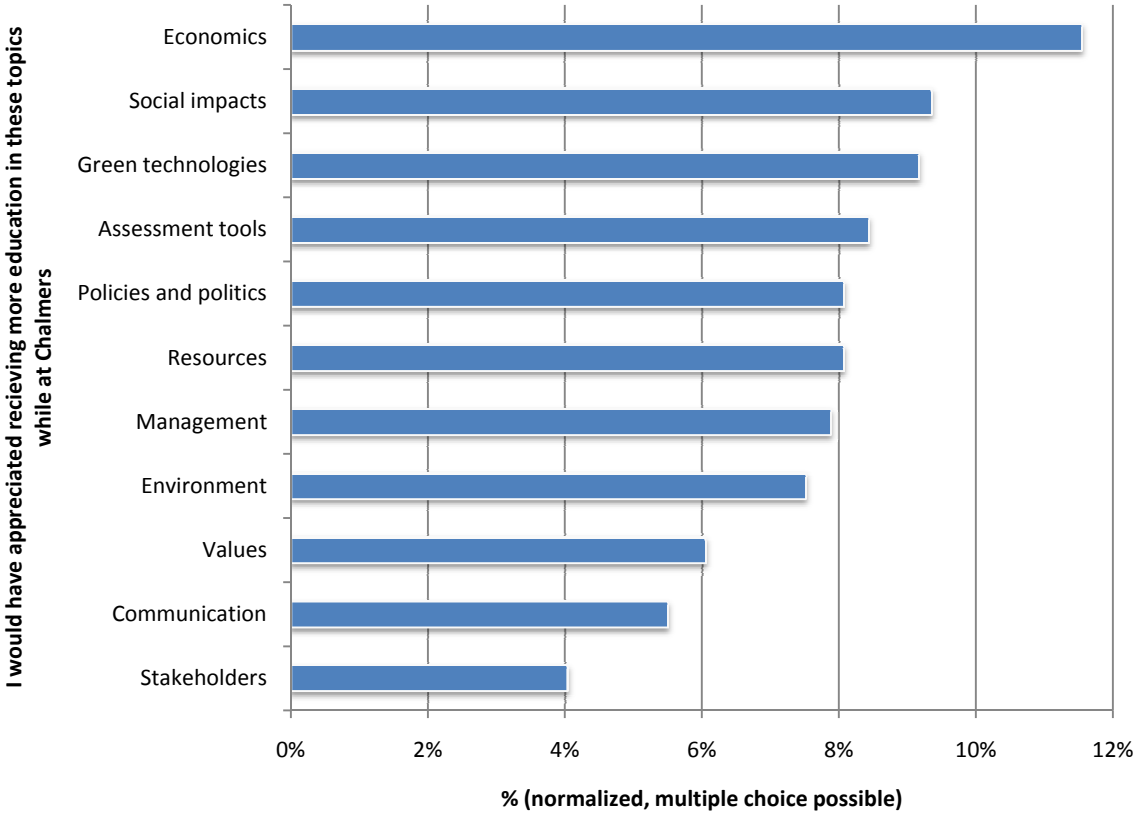


Figure 35: I would have liked to get more knowledge in this area while studying at Chalmers. (Survey: authors' alumni survey).

When analyzing what categories the respondents regards as the most important knowledge areas when working with SD, another set of categories emerge where environmental and economic studies are the primary areas stated. Most respondents believe knowledge in environmental issues to be the by far most important category. This can be related to the inventory where we see that the bachelor programs educate mostly in environmental studies. The second most important category is said to be economics. This area, on the other hand, is the area where most respondents feel they did not get enough knowledge in during their studies at Chalmers, see Figure 36.

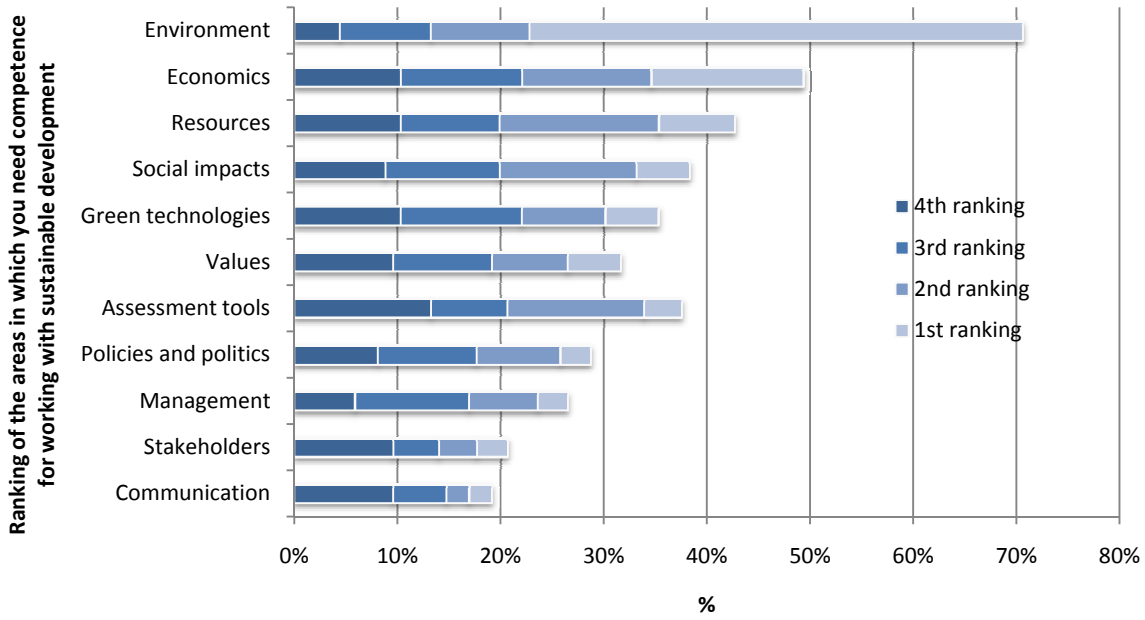


Figure 36: Rate the most important categories in which you need competence to work with sustainable development. Notice that the respondents comment that you need knowledge in environment and economics the most. (Authors' alumni survey)

Finally, the respondents were asked to look into the future and give their thoughts on the development of environmental and SD issues at their workplace. A clear majority (75 %) believes that environmental and SD issues will become more important to their employers in the future, see Figure 37.

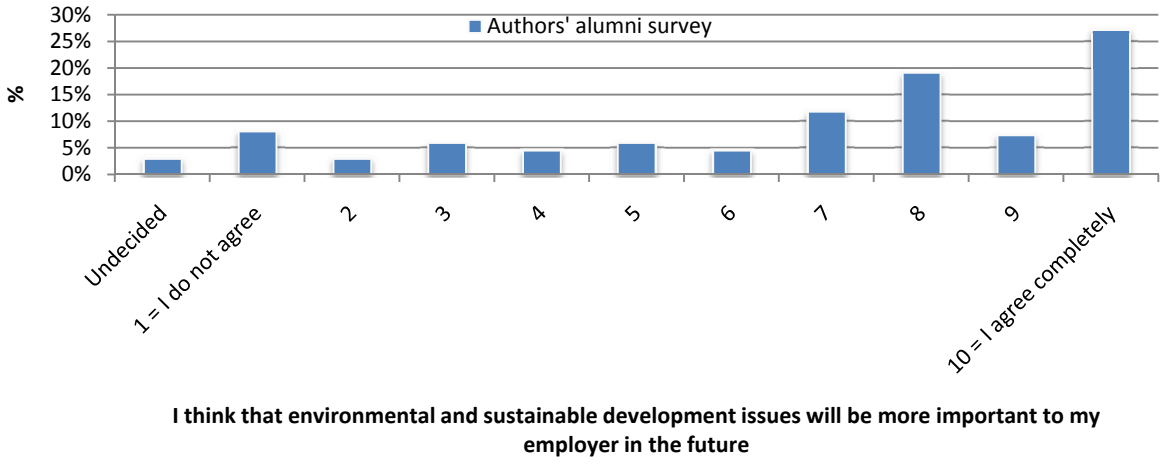


Figure 37: The respondents believe environmental and SD issues to be more important in the future. (Survey: authors' alumni survey)

As an additional remark, the present students at Chalmers were asked how they preferred the subject environment and SD to be taught at Chalmers. A clear majority preferred the subject to be integrated in some, almost all or all courses, and only 8 % preferred a separate course, see Figure 38.

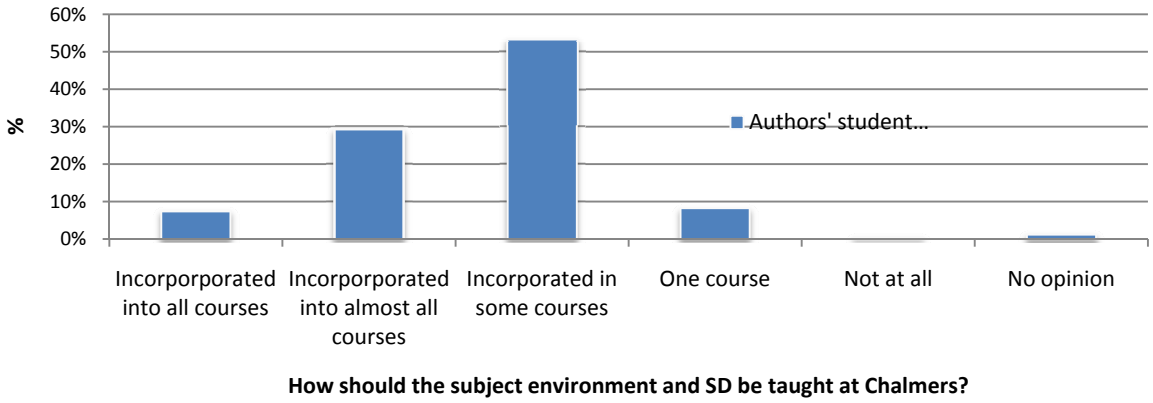


Figure 38: The present students at Chalmers prefer the subject environment and SD to be integrated in other courses. (Survey: authors' student survey)

15 Quality of the survey

The quality of surveys is based on a wide variety of issues and aspects to consider are question formulation, understandability, survey sample and the respondents' understanding of the survey questions. In order to come to terms with the understandability of the surveys, the surveys where sent to a small group of people for testing. This group reported back to the authors with comments on improvements in order to make the survey more understandable, and hence the understandability was increased to a satisfactory level.

An aspect of validity is related to whether the survey respondents even started the two surveys or not. The invitation email sent to the respondents stated that the survey dealt with SD, which means that those who are clearly not interested in the subject might have decided to not answer the survey altogether, based on the invitation. The survey might therefore have addressed people more interested in the subject than not, meaning that the answers might have been slightly more positive than otherwise. The contrary might also be possible where respondents not interested in SD issues wanted to speak out against the topic hence giving a more negative view.

In order to grasp whether the respondents had any thoughts of their own regarding the subject, the possibility for them to leave free-text answers should have been given. However, the authors' time constraints did not give enough space for an analysis of such results, hence the possibility of leaving free-text answers were omitted in the two surveys. Still, free-text answers might have given some more insights into the way the alumni are working with SD issues and the way the students comprehend their SD courses.

The survey sample for the authors' alumni survey was chosen to be the same sample as during Chalmers alumni survey. The reason for this was the possibility to recreate some questions from Chalmers alumni survey in order to see if the respondents answer in a similar way in the authors' alumni survey. The respondents did answer very similarly across the two surveys hence the two groups of survey respondents can be seen as fairly similar. The survey sample was thus satisfactory, since the targeted group answered similar as to the alumni group of Chalmers alumni survey. The sample in the authors' student survey can also be seen as a satisfactory match to the criteria set up before sending the survey. It was almost exclusively third year students who answered the survey, and in some programs very high response rates were achieved.

Validity is also based on how true the respondents are to their answers. It might be an easy way out for the respondents to answer in a way that they "should" answer, even if they do not know the answer (Saris & Gallhofer, 2007). One question relating to reliability of both of the authors' surveys concerns questions asked about SD issues and in particular, the questions related to the respondents understanding of the concept. It may be difficult for the respondents to give a reasonable answer to a question regarding what type of knowledge they might be lacking, since a lack of knowledge might mean that they do not know anything related to the subject. This means that their answer might be to poor in terms of analysis, since it may only reflect a notion rather than the reality.

Another weakness of the surveys is the time lag between the time of education and the survey. The alumni, for instance, might have taken a course in environment and sustainable development as early as in 2001 or 2002, and might have a hard time recollecting what the topic was all about. The student survey is facing the same problem, since the students in different programs are subjected to SD courses during different times in their education. This might inflict on the homogeneity of the survey sample, since the respondents might have different opinions in SD because of the time issue, and not because they were subjected to different types of environmental and sustainable development courses.

" – Systems perspective is important. Engineers are good at delimiting even though everything is integrated. To include all when approaching problems and to see totality /…/ there are no isolated problems /…/ you have to think transboundary"

- A sustainability director at a manufacturing company [22]

Part 5: DISCUSSION

In this part, all of the collected results from the course content inventory, company interviews, alumni and student surveys, and focus group discussion are compared. This is done to identify patterns, similarities and dissimilarities between the course contents supplied at Chalmers, the competence needs of the companies according to the company interviewees, the future societal needs of competence according to the focus group, and the survey results regarding the alumni competence needs and the students' opinions on the education at Chalmers. It is also assessed in relation to previous literature in the field and to Chalmers rules and regulations regarding ESD. The results are discussed as a whole in order to give the reader a good understanding of the implications of all findings in this thesis. The discussions then form a basis for the conclusions and recommendations presented in part 6. A discussion on the methods chosen and their respective obstacles is also included so as to give the reader an insight in why some types of conclusions cannot be drawn.

16 Interpretation

The interpretation is divided into four parts; why and how companies work with SD, competence needs in SD, outlook of future needs of competence in SD, and lastly a discussion on the methods used.

16.1 Why and how companies work with sustainable development

The first part of the interpretation is mainly based on the interview results from the categories discussing 'company structure and view on sustainable development', 'business reasons for working with sustainable development and how companies work with the issues', and 'company communication and understanding sustainable development'. The interpretation is complemented with survey results and references to literature previously mentioned. The following section discusses the underlying reasons for conducting SD work, how SD work is conducted today and if communicating SD is a problem.

16.1.1 Underlying reasons for conducting sustainable development work

Strategy, profit, costs, risk, brand and reputation are stated as strong influences to why companies work with SD according to the company interviewee. The alumni survey reinforces the interview results by showing on similar results where strengthening brand and reputation, meeting consumer demand, and economic profitability are seen as the top three underlying reasons to why companies conduct sustainable development work. These results also correspond to the literature previously described which mentions the following possible benefits and risks of pursuing SD work. Reduce costs, portfolio differentiation, creating innovative new products and processes, improving image and reduce risks are possible benefits while negative publicity, legal risks and lost business opportunities are possible risks. Additionally, present students at Chalmers seem to be aware of what the present underlying reasons to why companies conduct SD work are. The student survey gave results similar to the alumni with strengthening brand and reputation, meeting consumer demand and economic profitability as the top three underlying reasons. See sections 10.4 and 2.5.3, and Figure 17.

Even though most results regarding underlying reasons for conducting SD work seem to correlate, one large difference between the alumni survey results and the company interview results is how influential risk management is on conducting corporate SD work according to the different groups. While the interviewed companies regard it as a main driver, the alumni rate it as a relatively low driving force. This may show that companies realize both potential benefits when working with SD and potential risks when not working with SD, while alumni tend to see only potential business opportunities and possible environmental and social benefits. The difference in points of view may be related to that the interviewees and alumni do not exercise the same work tasks. The student survey shows on similar results to the alumni survey. See section 10.4 and Figure 17.

While the interviewees only spoke of business related reasons to why companies work with SD, the alumni also told of environmental and social driving forces. According to the alumni, additional influential drivers are protecting the environment, to be a good corporate citizen, and to contribute to the local community. The literature taken into consideration also mentions the environmental reason of protecting natural resources. One plausible explanation to why alumni regard environmental and social aspects to be underlying reasons to why companies conduct SD work, whilst the companies themselves do not, can be derived from how companies are viewed today. Parts of the society today view companies as corporate citizens with responsibilities rather than economic institutions with profitability as main goal. Companies would have different SD agendas depending on if they act as corporate citizens or economic institutions. The results obtained may indicate that while the interviewed companies view themselves as foremost economic institutions with business related reasons for conducting SD work, alumni also view them as corporate citizens with a social and environmental agenda additional to the economic agenda. The

students' view of underlying reasons for companies to work with SD corresponds fairly well to the alumni's view. It may be that both students and alumni approached the question as citizens of a society rather than being impartial, hence the answers may show some wishful thinking as well. See Figure 2, Figure 3, Table 5, and Figure 17.

16.1.2 How sustainable development work is conducted today

The literature review on 'the industry's work with SD through corporate environmental and social responsibilities' indicates that environmental and social responsibilities of companies have developed as two separate issues and the interview results show on a continuous separation of the two. The results from 'company structure and view on sustainable development' show that only 5 of the 16 companies integrate their social and environmental work while the other 11 treat them as separate issues. According to Hitchcock & Willard (2009) a transformation to integrate the two issues occurs over time. The two ways of working with SD, depicted in Figure 39 below, the figure to the right represents the five companies which have experienced the entire transformation towards integration while the figure to the left represents the eleven companies which do not integrate the two aspects. The economic limits are the outermost boundary since all companies are economic institutions. See sections 2.5 and 10.1, Figure 3.

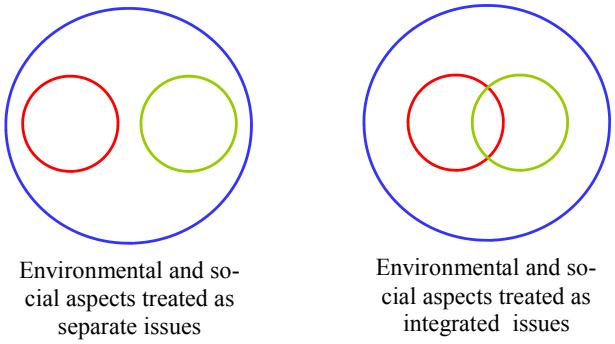


Figure 39: The figure depicts companies working as existing institution with economic outer boundaries. The image to the left depicts a company which works with environmental and social aspects as separate issues. The image to the right depicts a company which works with environmental and social aspects as integrated issues.

The company focus has historically continuously shifted between environmental and social aspects due to events and societal pressure. Additionally, the company interviewees mention that the working tools used for the two types of issues are different. While environmental work most often can be calculated in monetary terms, social aspects sometimes cannot.

> *" – We address both economic, environmental and social aspects but when we make calculations for business decisions it is more difficult to include also the social aspects."*
>
> - A sustainable development manager in a manufacturing company [20]

The reason to why a majority of the interviewed companies have separated the environmental and social issues may depend on the historical development of SD work and on how easily it can be related to company operations. From an engineering point of view it may be easier to apply technology to strive for environmental sustainable development than social sustainable development. For this reason, and the above stated reality that environmental and social issues are most often dealt with separately in the interviewed companies, it may be concluded that engineers with an ability to regard or to work with social issues may neither be essential nor sought for today. However, it may also be that because of the separation of the issues in companies, engineers should know how to regard social issues in addition to environmental issues, as an attempt to bridge the gap between the two. And if the future trend is that the two issues

merge as the view according to Hitchcock & Willard (2009), future engineers might need to possess knowledge in all three fields; economic, environmental and social. See sections 2.5.1 and 2.5.2.

The majority of the approached alumni, 54 %, state that they have a business management that clearly supports work contributing to sustainable development, 25 % have not and 21 % do not know. However, even if there is a supportive management, only 62 %, of all alumni, is encouraged to regard SD in their daily work. The discrepancy between overall support and encouragement in daily work may depend on several reasons, but one possibility is that the companies with a supportive management, which do not encourage their employees to regard SD in their daily work, only communicate the support to external stakeholders in order to protect or enhance their brand, image or reputation. Nevertheless, since the focus group results point at a plausible continuous trend of increasing focus on corporate SD work in the future, it may not be possible to use SD only as a façade much longer hence SD may need to be incorporated in company operations as well. If it is an increasing trend for companies to incorporate SD in its operations the demand for competences in SD amongst engineers may increase. See section 10.8, Figure 32 and Figure 33.

16.1.3 If communicating sustainable development is a problem

The interview results based on the category regarding 'company communication and understanding sustainable development' can be compared to how many of the alumni, who are responsible for the SD issues in their work, who can relate the company SD targets to their work. The category spoke of perceived problems with communication and troubles with understanding how the daily work related to SD amongst employees of some of the interviewed companies. However, 57 % of the alumni who encounter SD issues daily or sometimes, state they can relate the company SD targets to their work, whilst only 19 % cannot. The less regularly the alumni work with SD, the less they can relate their work to the company SD targets. Additionally, a total of 72 % of the alumni who are responsible for SD issues in their work can relate to company SD targets whereas 28 % cannot. The interview results and the alumni survey results do not correspond since the perceived problems with communication and understanding the relation between SD and daily work amongst the interviewees are not confirmed by the alumni. The perceived communication problems according to the interviewees may be fictive or the alumni do not know that they do not understand the directives or information communicated. Another possibility is that the interviewed companies do have communication problems and the companies, where the alumni work, do not. See section 10.5, Figure 27 and Figure 28.

16.2 Competence needs in sustainable development

The second part of the discussion covers competence needs and how they should be addressed, both at companies and at universities. This topic has been covered in the second category, 'responsibility of education and the need of generalist or specialist engineers in sustainable development', and has also been investigated through the authors' alumni survey where the competence need among Chalmers alumni was assessed. The discussion will cover the areas; the perceived competence and educational needs and work related competence needs, all as seen by the company interviewees and Chalmers alumni.

16.2.1 Perceived competence needs in relation to the education at Chalmers

The authors' alumni survey and company interviews depict a need for knowledge and competences in SD amongst engineers, where the majority of the survey respondents both from the authors' survey (71 %) and Chalmers alumni survey (65 %) say that they received very limited or limited knowledge in environment and SD. This result can be elaborated on further by examining the question on whether the alumni think they are well enough prepared to develop products and processes with regard to SD (as it is expressed in the MScEng degree ordinance). In the authors' alumni survey 65 % answer that they are very poorly, or quite poorly prepared to develop products in regards of SD, and in the Association of Graduate

Engineers alumni survey, 58 % say they are very poorly or quite poorly prepared to do so. From these results, spanning from two different questions in the three different surveys (the authors' alumni survey, Chalmers alumni survey and the Association of Graduate Engineers alumni survey), we can conclude that Chalmers' alumni perceive that they have received too little education in environment and SD while studying at Chalmers. See Figure 18 and Figure 20.

In order for Chalmers' rules regarding environmental and SD content in the education to be truly effective, the figures presented above should have been drastically different and the results should have looked more like the envisioned graph presented below, where the authors envision future respondents who show on a larger attained knowledge in environment and SD. Chalmers' vision encompasses a view that "the education should give tools and an understanding to develop technologies for the society in sustainable systems" (Chalmers, 2008b). Clearly this vision is not met at present, since a majority of the alumni do not feel that they have received enough formal knowledge in SD. See section 2.3.1 and Figure 40.

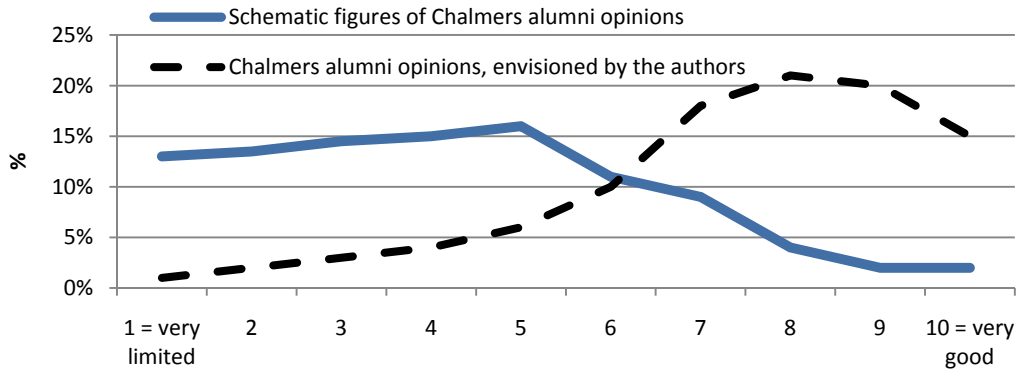


Figure 40: Schematic picture of Chalmers alumni opinions (smoothed) on whether they have attained knowledge in environment and sustainable development whilst studying at Chalmers, and the authors' envisioned opinion curve. If Chalmers' education in SD were to be effective, the answers should fall into the range of the envisioned curve.

The approached alumni graduated either in 2005 or 2006 which means that they might not have been as subjected to SD at Chalmers as the students are today, resulting in a lesser understanding of SD among the alumni and a lesser understanding of what SD issues are. The requirement for passing a course in SD was not put in place for the five-year engineering programs until 2003 and for three year engineering programs until 2007. From the authors' alumni and student surveys, it is evident that more present students than alumni have come into contact with SD while at Chalmers. Only one percent of the third year students say they have not come in contact with SD at Chalmers, while 12 % of the alumni answered that they did not come in contact with SD while at Chalmers. It is possible that the approached alumni never came across SD at Chalmers, but it is also possible that they do not recall taking a course in SD, since it was some time ago. See Figure 23. However, the majority of the alumni ought to have come in contact with SD, since most of them were subjected to the rules regarding the mandatory 7.5 higher educational credits in environment and sustainable development. This means that the alumni should have come in contact with SD while at Chalmers, but according to the respondents this was not enough.

In order to come to terms with the perceived lack of competence, Chalmers' indicative text for learning outcomes is a good groundwork for creating engineers with knowledge and competences in SD, though

the indicative text must be improved with information regarding sustainable business development in order to meet the industry's needs. The indicative text for learning outcomes states that the intended learning outcomes in a mandatory course on environment and sustainable development should involve recalling basic facts about the state of the world regarding population growth, human needs, resources, technological systems and the problems that arise in the relation between humans and the environment, all of which has been asked for by the interviewees as being important knowledge for understanding SD. The indicative text for learning outcomes also mentions that it is important to explain the complexity which encompasses meeting human needs within the limits of the environment, which includes human relations, inter-generational justice and democracy, which are also important aspects according to the company interviewees. Moreover, long sightedness and ethical considerations are important according to the indicative text for learning outcomes, and the company interviewees agree. The indicative text for learning outcomes also regards communication across professional and disciplinary boundaries as important, as does the company interviewees. Finally, the indicative text for learning outcomes mentions treating large-overarching problems by identifying smaller manageable sub problems as important. The company interviewees have commented that the engineers of today are good at solving problems, and that they are good at taking care of specific problems, but they lack the capability of seeing problems from a systems perspective. Hence, all of the areas mentioned in the indicative text for learning outcomes are seen as important engineering competences and demanded for by the companies, and today most engineers lack competences in these areas. Moreover, the indicative text for learning outcomes does not explicitly state economic aspects and sustainable business development as an important SD issue, which is something the companies also see as a lack of knowledge among their employees. See section 4.4, 10.2 , 10.5 and 10.7.

The indicative text for learning outcomes can also be used to discuss the present education at Chalmers, where most mandatory courses in the five-year engineering programs do not meet the standards set out in the indicative text for learning outcomes, thus a need for further assessment and evaluation of the courses on environment and SD is needed. From the five areas previously mentioned, the most prominent missing knowledge area is communication. Some programs claim to have incorporated SD issues in courses like "academic communication" however, according to the inventory there are no explicit SD courses discussing communication in an SD perspective. Another area which is not met to a satisfactory degree at present is the issue of understanding ethical considerations, since few of the mandatory courses in the five-year engineering programs speak of such issues. Recalling basic facts about the environment is clearly met by most programs, since environmental issues are taken seriously and they are the most prominent course content found through the course content inventory. Explaining the complexity of meeting human needs and inter-generational justice is also an area which is overlooked by the mandatory courses. Economic and management issues regarding SD, is also overlooked by the mandatory courses, since very few of them have course contents in that area. See section 4.4 and section 6.2.1.

A concluding remark of the perceived competence needs and the comparison to the education at Chalmers shows that the areas covered in the indicative text for learning outcomes are not met at present, and the indicative text for learning outcomes should also incorporate sustainable business development, economic, and management areas relating to SD in order to be complete from a company perspective.

16.2.2 Work related competence needs

The alumni need competence in SD in order to manage their daily work. 52 % of the respondents in the authors' alumni survey state that they are responsible for SD aspects related to their daily work. 35 % of the alumni mention they encounter SD issues in their work daily or sometimes, but only half of them (47 % out of the alumni that encounter SD issues in their work daily or sometimes) state they possess enough competence in order to make decisions from an SD perspective. Additionally, 27 % of alumni states there have been occasions when they have not possessed enough competence to deal with SD issues properly. The fact that only one third of the alumni who encounter SD issues believe they possess enough

competence to work with the issues speaks of a need of greater knowledge and competences in the field amongst educated engineers. Hence, there is a gap between the competence needed to work with SD and the knowledge supplied by the education, since many alumni feel that they do not have enough competence to carry out their responsibilities regarding SD issues. However the reader should bear in mind that it is also possible that the alumni may not possess enough competence to neither identify all SD issues they encounter, nor know if they possess enough competence to solve problems in the best way possible. The above described competence gap corresponds well to the company interview results where most interviewees ask for a higher basic competence in SD among the engineers. According to the interview results, engineers should have a greater basic understanding for the natural resource constraints that face our world and economic constraints and possibilities regarding SD. According to the authors' alumni survey, the two most important aspects where knowledge is needed in order to work with SD are environmental and economic aspects. Resources and assessment tools come in as the third and fourth most important aspects according to the alumni. See section 10.2 and Figure 24, Figure 25, Figure 31, Figure 34 and Figure 36.

The company interview results show that the companies prefer a higher basic knowledge of SD amongst their generalist engineers, as opposed to only employing more SD specialist engineers. As stated above, the authors define a generalist engineer as "an engineer who has a specialty in an engineering field but has additionally taken a mandatory course in environment and sustainable development" and a specialist engineer as "an engineer who has a specialty in a sustainable development field". However, they seem to work with a wide range of assessment tools and other methods that would need specialist competences to execute. Hence, even though the companies demand higher basic competence in the generalist engineer, they still need specialist engineers who have taken advanced courses in different methods to be able to work with SD. Though, as several company interviewees have mentioned, a majority of the students should still be generalists with specialist strength in an area other than SD. This goes in line with the information on how many students that study a master program in SD and the amount of students that study other master programs, where at present 10 % of the students at Chalmers follow an SD master. See section 10.2, Table 15 and Figure 23.

16.2.3 Need of integrated education for sustainable development

Several company interviewees mention that they are integrating SD as an important part of their business and they also mention that the entire engineering education should be infused with SD. One company interviewee [30] mentioned that SD should not become another add on, but instead it should be integrated in the different courses where sustainable methods can be showcased. A recurring topic concerns the possibility to connect SD to the professional role of the engineer. See section 10.2.

Many of the company interviewees see a distinct lack of knowledge amongst newly graduated engineers when it comes to SD and as a result, some companies have started their own education within SD. The internal education programs also aim at spreading company values and creating a common awareness platform around the company's business. This means that the companies might still have conducted these internal educations on SD, had there been better knowledge amongst the engineers, since the companies will want to spread their company values regarding SD. Some of the interviewees have mentioned that this is the case, and that if the engineers would have a better understanding of SD issues, their internal education programs might be able to aim at a much higher level of knowledge than at present. See section 10.2.

There is evidence that good integration of SD education enables the students to attain higher insight into the concept of SD and gain a greater understanding of the relevance of ESD. The three bachelor levels at the Master's programs in engineering at Chalmers; mechanical engineering, chemical engineering, and industrial engineering and management, all have SD integrated over several courses. The chemical

engineering and mechanical engineering programs also have a dedicated course in SD, complemented with integrated SD elements in other courses. The industrial engineering and management program, on the other hand, does not have a separate introductory course in SD, which results in a lesser coverage of SD areas than in the other two programs. Still, the students' perceived insight into the concept of SD is high in all of the three programs mentioned. The authors' student survey also shows that the students in all the three programs with well integrated SD elements regard SD as something highly relevant for their education. See section 6.2.1, Table 13, Figure 8, Figure 21 and Figure 22.

A program with less integrated SD elements gives the students less understanding of the relevance of SD issues, though they might still have a good insight into the topic of SD if they have had a comprehensive basic course on SD. The computer science and engineering program, which has a comprehensive SD course, has the largest amount of students who do not see SD issues as relevant for their education according to the authors' student survey. This might be attributed to the fact that SD is less integrated in the regular courses at the computer science and engineering program, even though they have an exhaustive course on SD according to the course content inventory. Still, since the computer science and engineering students have a comprehensive course on SD, they show a good insight into the concept of SD. This shows that in order for SD education to be effective, it needs both a basic course covering the basics in SD, and well-integrated course elements throughout the program curriculum. Another aspect of integrating SD elements can be seen when analyzing the engineering physics students who show that they have a lesser perceived insight into the concept of SD, combined with less integration throughout the program and a not so comprehensive course on SD. See section 6.2.1, Figure 21, Figure 8 and Figure 22.

All results combined show that SD will become relevant and more understood as a concept to the students if they are taught the subject in one or two comprehensive SD courses, and at the same time receive integrated SD topics in an array of other courses. Thus, integrating SD into the education enables students to understand how SD is relevant for their future engineering career and creates an understanding of how students can connect SD to their future profession. Additionally, 82 % of the present students at Chalmers want their education in environment and SD to be incorporated into some or almost all courses. See Figure 38.

16.3 Company and focus group outlook and different methods for working with sustainable development in the future

When analyzing the company outlook into future SD work, it is important to interpret both the timeframe of the company goals and strategies, what tools they are working with today, and what areas of SD the companies believe they will focus on in the future.

The authors' alumni survey shows that the respondents express an idea of the importance of SD issues in the future, where 70 % of the respondents express the view that environmental and SD issues will become more important to their employer in the future. This result supplements the results from the interviews where all of the interviewees state that focusing on SD is a business strategy for company survival. The interviewees also comment that not focusing on SD is not an option, because the importance of SD will not decrease. The focus group discussions also confirm the importance of sustainable thinking throughout society at large. See Figure 37.

The alumni voiced the importance of SD through the authors' alumni survey, where they pointed out environmental and economic issues as being the two most important areas to work with in regards of SD, but also believe assessment tools to be an important aspect of SD. The results from the company interviews show that the companies mostly demand for engineers that understand SD issues at a basic level, but they want that level to be higher than present. A sustainability manager at a manufacturing company [30] commented that it is important for the engineers to know basic aspects of SD, because they

can then use the companies own methods, like their simplified Life Cycle Assessment, which is meant to be used by generalist engineers. The same company had three experts working on Life Cycle Assessment, but most regular engineers were supposed to be familiar with the simplified version, hence a better basic understanding was the most important aspect of competence in SD. See section 10.7.

It was difficult to come to a general conclusion on what assessment tools, or what subjects that mattered most to the companies, however a couple of the companies have mentioned working with LCA, and it was the only assessment tool that was discussed during several interviews. Hence, its importance must be seen as relevant. Other assessment tools discussed during only one or a few interviews were; Design for Environment, risk management, bio-mimicry, energy mapping and Cost Benefit Analysis. These can be seen as an excerpt of tools and methods used by the companies today, and they may become more important in the future. However, a more thorough investigation regarding specific company needs must be conducted in order to assess the exact needs. See section 10.7.

In the context of future development of the SD issues, the focus group discussed the possibility that other issues than the presently discussed ones, for instance energy and climate, will become more important in the future. Today much focus is directed to environmental and climate issues when discussing SD issues, but the focus group concluded that these issues will have to share their space with other issues, like resource use and other social and economic issues. See section 10.8. Another important aspect of future development of SD issues voiced by the focus group was the growing concern of SD issues, not only in consumer end-products, but also in all steps in a value chain, hence more companies need to get more involved with SD issues. As a result, companies may need to change towards more long term strategies since SD investments may have longer pay back times. As a result, more engineers must become better at communicating the benefits offered by SD innovations towards society, in order for society to make relevant SD choices concerning products and services. See section 10.8.

The society at large probably lack knowledge in SD which makes it difficult for people to make relevant choices when it comes to choosing between sustainable and unsustainable products and services, thus the universities may have to take action since they educate future decision-makers. They therefore hold the responsibility to align education in SD directions. According to the focus group, consumer demand and authorities will be the largest driving forces in generating a more sustainable society; hence the universities must address the lack of knowledge in SD issues in society. Most companies will only follow authorities and consumer demands hence there must be a raised awareness in society at large in order for a change to take place. See section 10.8.

In regards of integrating education for SD in all engineering programs, the focus group discussed the importance of giving examples in a relevant context, and the focus group believes it to be important to integrate SD in all programs. They also mentioned that integration is more important than having a separate course since according to them, integration is more effective. Integrating SD in more courses would also be beneficial because it would not necessarily mean replacing other knowledge areas. See section 10.8.

16.4 Discussion on the different methods used

The choice of methods used affects the quality of the results hence a critical discussion of the methods used is preferable. In general, the methods used for collecting data have, according to the authors, been satisfactory. Below follows a discussion on what the different approaches taken have meant for the results and what other approaches that, in hindsight, may have been useful or sometimes even a better choice.

Regarding the inventory, the authors could not identify an already defined structure on how to analyze such material as course content and learning objectives hence the authors chose to combine commonly used educational and learning taxonomies with own ideas to create a suitable method. As a consequence,

all inventory results are, to some extent, based on the authors' own interpretations of the material rather than what knowledge and competences are available at Chalmers. Additionally the delimitations made regarding what courses the authors decided to include in the inventory may be a limited selection rather than a good showcase of what is actually available. A more extensive search would have given more detailed results of a higher quality. However, time constraints did not allow for this.

Using interviews when investigating company demand was a good choice since the method allows for follow-up questions that are necessary if you want to identify the reasons behind an expressed need. The authors' intention was primarily to identify what specific knowledge or competences the different companies demanded, however this had to be revised due to the sample of interviewees chosen. The authors only interviewed people who had an idea of the overall demand, however the interviewees at the companies often had a strategic rather than operational role, hence very few actually performed the applied engineering work in question themselves. Due to this, very little detailed information on the specific competences demanded for could be collected.

Due to a somewhat narrow and uniform sample of company interviewees, the authors decided to expand the project with an additional method using a survey to address Chalmers alumni. The aim of the alumni survey was two-fold. Primarily, it aimed at confirming the results of the company interviews, and secondary it was aimed to expand the interviewed sample to include a wider range of professional roles approached. Seeing that very few of the alumni approached work with SD as their main work tasks, the alumni survey served its purpose. The survey was, however, somewhat too extensive and even though the answering frequency was high, several respondents did not follow through with the entire survey, hence the total numbers of usable responses were a bit less than the total amount of respondents.

The student survey was primarily made due to the authors own interest in the topic and was not planned from the beginning. It however proved to be of interest of the thesis when the alumni survey was created and the answers collected from the student survey gave additional input to the inventory results. The survey was kept very short in order to increase a higher answering frequency. However, in the end the authors felt that a more extensive survey may have given more detailed results. For instance, giving the respondents the possibility to give free text answers might have given a more varied picture of the education at hand, though time constraints regarding the survey analysis made it difficult to add such a feature to the survey.

17 Quality of the interpretation

Since the research is of an investigative nature, the validity and reliability of the results should be evaluated, to assess if the quality of the results is satisfactory for the research to lay as groundwork for decision-making or further research. The study is reliable if the collection and interpretation of the data is trustworthy. A thorough description of the method used and a third person review of data and analysis can increase the reliability. The sample selection also influences the reliability (Höst, Regnell, & Runesson, 2006).

The interpretations of the collected data were made by the two authors only. Neither was there a third part review of the interpretation nor is there an explicitly stated method for the interpretations. However, throughout the discussion there are references to all interpretations made based on data collected, so the reader has all possibilities to consider the data used as the basis of the interpretations. The authors hope it is obvious to the reader wherever the authors have presented results purely based on collected data and where their own thoughts and speculations on the data results are presented.

" – What we see now, what we focus on, that will not decrease but rather increase. Globalization occurs and /…/ through that perspective we will gain an enhanced engagement in these types of questions. You will not speak of environmental and sustainability issues as we do today but it will be an integrated part of our business, a natural part"

- A sustainability manager at a manufacturing company [30]

Part 6: CONCLUSIONS

This part accounts for the conclusions drawn from the discussion in the previous part. The conclusions aim to meet with the aim and objectives of the master thesis. The conclusions also fall into recommendations to Chalmers University of Technology regarding its education in sustainable development at Bachelor of Science level in the three- and five-year engineering programs. Potential areas of future research have been identified based on delimitations and problematic areas at Chalmers, and are also presented in this part.

18 Conclusions

One aim of the master thesis was to identify what SD competences companies utilize today and what competences are predicted to be sought after in the future. This was done by examining the business demand for knowledge and competences within the field of SD, examining the knowledge supplied by Chalmers within the same field, and comparing the two. The following paragraphs are conclusions drawn from the study.

The majority, 11 out of 16 of the interviewed companies do not work with SD as one concept but separates it into environmental and social issues. This has the effect that at most companies, the social issues are most often dealt with through a Human Resource department, while the environmental issues are dealt with through the environmental department or environmental manager(s). The inventory results show that the education at Chalmers deals with social issues only in very few courses and just as introductory material.

The company interviewees, the approached alumni and the approached Chalmers' students more or less share the same view of what the underlying reasons to why companies engage in SD issues are. The majority of the company interviewees state their respective company views its interest in SD issues as a business strategy developing its business, processes or products; as a way of increasing profits or reducing costs; managing risks and strengthening brand and reputation. This view on SD is also shared by the students and alumni. A noticeable difference in points of view is however that the company interviewees seem to view companies as business entities with an economic agenda to a larger extent than the alumni and students. Instead, the alumni and students tend to view companies as corporate citizens to a larger extent. Hence, the alumni and the students share the view that the companies should take on more responsibilities in society, than what the company management is doing at present. Even though the company interviewees, Chalmers alumni, and students have similar opinions about what reasons companies have for engaging in SD issues, these reasons are rarely dealt with during the education at Chalmers. Economic and management aspects relating to SD issues are almost non-existent in the mandatory courses in the five investigated master programs and in the mandatory courses on environment and SD in the five-year engineering programs.

Almost three quarters of the alumni in the authors' alumni survey state they believe environmental and social issues to be of greater importance for their employer in the future. Additionally, all interviewed companies state that they have to focus on SD issues today and that the importance of working with SD issues will not decrease over time. This coincides well with Chalmers' visions regarding ESD which is to "permeate all programs" and where all students should have a basic understanding of SD issues (Chalmers, 2009e). Hence, Chalmers visions are in line with the development of the Swedish industry. Chalmers vision for 2015, which states that working engineers should be able to improve their competence in SD at Chalmers, also lies in line with the opinions of the company interviewees, who state that they need to raise the overall competence at the companies (Chalmers, 2009e). This means that Chalmers could take part in such a transformation and hence be a part of conveying SD knowledge to working engineers even after they have left their studies at Chalmers.

The company interviewees experience a greater demand for engineers with a technical specialty, but which possess generalist knowledge and competences in SD. The knowledge and competences in SD should be considered as a higher general competence of the underlying reasons to and issues in SD, but should also be related to the engineers' future professional role and coming work assignments. According to the company interviewees and the focus group, this can be achieved by integrating SD issues in relevant topics during the education, which results in a higher understanding of the SD issues in relation to their future working role. This is something that has been done effectively in some of the programs at Chalmers, but the process has to take place at all three- and five-year engineering programs, since there are still many

programs lacking any form of integration regarding SD issues. It is difficult to assess the number of generalist versus specialist engineers needed, though the current situation at Chalmers where 10 % of the students enrolled in an MSc program are studying an SD program might be a good number.

Internal education exists amongst many of the interviewed companies, partly to fill a knowledge gap and partly to convey company norms and values. Though, the interviewees regard universities as the most important institution responsible for teaching SD, and they regard SD issues as something that should be incorporated into the engineering education. Even if the SD education was improved at the universities, the companies would still have internal educational programs in order for them to convey company norms and values, but they have also expressed the view that with a greater general understanding of SD issues amongst their employees, the internal education could focus even more on SD in relation to the company and specific working-roles.

The approached alumni believe they have gained too little knowledge and competence in SD at Chalmers. Approximately two thirds of the alumni who encounter SD issues daily or sometimes in their work believe they do not possess the competence needed to handle the issues properly.

The education for environment and SD in Chalmers five-year engineering programs is mainly focused on environmental issues today. The recommendations outlined in the indicative text for learning outcomes are not implemented fully at any of the investigated programs, since all programs are missing one or more of the aspects outlined. Communication across disciplines regarding SD issues is almost non-existent as course content in the environment and sustainable development courses, and values, inter-generational justice, and ethical considerations are also insufficient throughout the education. Other areas raised by the company interviewees not educated in to a satisfying extent are economic and management issues related to SD, which the company interviewees see as important knowledge.

A comprehensive course in environment and SD may enhance the students' perception of insight into the concept of SD. Furthermore, if SD is incorporated in the mandatory courses Chalmers' students possibly gain a greater understanding of the relevance of education for SD and reckon them to have a greater understanding of SD than those who are taught SD as a separate course. The students also gain an understanding of how to incorporate SD in their professional work later on.

19 Recommendations for Chalmers

The authors recommend Chalmers to engage further in the following areas, which are all related to the education for environment and sustainable development that is today mandatory for all engineering students that pursue a three- or five-year engineering program at Chalmers.

The education for environment and sustainable development is today of varying, and sometimes maybe even of inferior, quantity:

- There are no detailed guidelines of what knowledge and competences in environment and SD Chalmers want their students to possess when they graduate. Such guidelines could be used by program coordinators when evaluating and assuring the qualitative standard of the mandatory course or course elements in environment and SD at the respective programs. The indicative text for learning outcomes is a good foundation for developing such guidelines. At present time the available text is lacking in details and there are no recommendations on how the implementation of environment and SD education should be conducted.

- At present, there is neither an authority nor instance that actually ensures that all students possess the required knowledge and competence in environment and SD. The today responsible

instances, Vice President responsible for Chalmers undergraduate and master programs and five-year engineering programs directors, are insufficient due to their hierarchical distance to the actual education process. Also, there is no authority which assess whether the education in environment and SD is satisfactory.

Present students want their education in environment and SD to be more integrated in the education than is done today. Companies wish for engineers who can relate sustainable development to their professional role and work tasks.

- There are many environment and SD course elements at Chalmers today which are only taught as separate issues and thus not put in relation to a future professional role.

20 Future research in the field of ESD

The first potential area where future work can be done is related to the three- year engineering programs. As stated above, there are no detailed guidelines of what knowledge and competences in environment and SD Chalmers want their students to possess when they graduate. Also, there is little or no available information on what type of knowledge and competences certain relevant industries want. Such guidelines could be used by program coordinators, or other authorities or instances, when creating, evaluating or assuring the qualitative standard of the mandatory course or course elements in environment and sustainable development at the respective programs. Furthermore, there are no assessment tools available for assessing how much the students actually attain of some types of competences when taking the courses on environment and SD. Potential areas of work are therefore;

- to identify what areas of knowledge Chalmers want their students to possess
- to create an assessment tool or strategy for identifying what specific knowledge and competences certain relevant industries need today or want in the future
- to identify what specific knowledge and competences certain relevant industries need today and want in the future
- to identify how guidelines for, or a course in, environment and sustainable development may and should look like and identify indicators for the level and quality of the education aiming at SD knowledge and competences
- to create an assessment tool for evaluating the quality and level of knowledge amongst students at Chalmers.

Additionally, there is little or no available information on what specialist competences in SD that are needed today. This is relevant information to the five-year engineering programs at Chalmers in order to assure that the programs educate engineers that are sought after. A potential area of future research is therefore assessing how the five-year engineering programs targeting SD can move forward with identifying what specialist competences in SD are needed today in order to assure that the programs only educate engineers that are demanded. This could also be relevant for the Masters program available at Chalmers.

REFERENCES

Bloom, B. S. (1956). *Taxonomy of educational objectives; The classification of educational goals; Handbook 1: Cognitive domain.* Philadelphia: David McKay Company, Inc.

Chalmers. (2008a). *Chalmers - för en hållbar framtid.* Lidköping: Strokirk-Landströms AB.

Chalmers. (2009a). *Chalmers alumnienkät.* (J. Malmqvist, Ed.) Retrieved 02 11, 2010, from http://document.chalmers.se/workspaces/chalmers/administration-och/informationsavdelningen/avdelningsmoten-kom/avdelningsmote-10/presentation-alumnienkat

Chalmers. (2005). *Den gemensamma kärnan.* Retrieved July 28, 2010, from Chalmers: https://document.chalmers.se/workspaces/chalmers/gmv/esd-chalmers/rapporter-delprojekt/den-gemensamma-karnan

Chalmers. (2009b). *Education: Joint rules and directives: Degree system; System of qualifications for degrees on the first, second and third level.* Retrieved December 7, 2009, from Chalmers: http://www.chalmers.se/en/sections/education/current_students/joint_rules_and_dire/degree_system/downloadFile/attachedFile_1_f0/System_of_qualifications_2007-07-01_rev_2008-12-22.pdf?nocache=1240831219.78

Chalmers. (2009c). *ESD - Lärande för hållbar utveckling, Chalmers, Mål 1-9*. Retrieved August 4, 2010, from Chalmers: http://www.chalmers.se/gmv/SV/projekt/esd_chalmers/mal

Chalmers. (2009d). *Master H09 - sökande, antagna, registrerade.* Retrieved 07 06, 2010, from Chalmers: https://document.chalmers.se/workspaces/chalmers/administration-och/studieadministration/statistik-ladok/master-h09-sokande

Chalmers. (2008b). *Miljö- och hållbarhetspolicy.* Retrieved April 22, 2010, from Chalmers: http://www.chalmers.se/sections/om_chalmers/miljo-och-hallbar/miljo-och

Chalmers. (2010). *Miljö och hållllbar utveckling inom utbildningen*. Retrieved July 28, 2010, from Chalmers: http://www.chalmers.se/sections/om_chalmers/miljo-och-hallbar/miljo-och-hallbar

Chalmers. (2009e). *Prioriterad verksamhetsutveckling 2010-2014.* (Rektor, Ed.) Retrieved April 22, 2010, from Chalmers Insidan - Verksamhetsdokument: http://www.chalmers.se/insidan/SV/om-chalmers/verksamhetsdokument

Chalmers. (2009f). *Rules for Master's thesis work.* Gothenburg: Chalmers.

Chalmers. (2009g). *Utskottet för pedagogik och kompetensutveckling.* Retrieved April 22, 2010, from Chalmers Insidan: http://www.chalmers.se/insidan/SV/utbildning-och-forskning/grundutbildning/sa-styrs/utskottet-for-pedagogik

Chalmers. (2009h). *Vägledande text om Chalmers obligatorium i miljö och hållbar utveckling.* Retrieved April 21, 2010, from https://document.chalmers.se/workspaces/chalmers/gmv/esd-chalmers/rapporter-delprojekt/vagledande-text-om

Crawley, E. F., Malmqvist, J., Östlund, S., & Brodeur, D. R. (2007). *Rethinking Engineering Education - The CDIO Approach.* New York, NY, USA: Springer Science+Business Media, LLC.

Dahlberg, O. (2009). *Nya ingenjörer om utbildning och arbete.* Stockholm: Sveriges Ingenjörer.

Fokkema, J., Jansen, L., & Mulder, K. (2005). Sustainability: necessity for a prosperous society. *International Journal of Sustainability in Higher Education , 6* (3), 219-228.

Gillham, B. (2008). *Forskningsintervjun; Tekniker och genomförande.* Lund: Studentlitteratur.

Grafström, M., Göthberg, P., & Windell, K. (2008). *CSR: Företagsansvar i förändring.* Stockholm: Liber AB.

Hitchcock, D., & Willard, M. (2009). *The Business Guide to Sustainability - Practical Strategies and Tools for Organizations.* London: Earthscan.

Höst, M., Regnell, B., & Runesson, P. (2006). *Att genomföra examensarbete.* Lund: Studentlitteratur.

Kolk, A. (2000). *Economics of Environmental Management.* Harlow: Pearson Education Limited.

Lourdel, N. (2005). *Méthodes pédagogiques et représentation de la compréhension du developpement durable: Application à la formation des élèves ingéngieurs.* Saint-Étienne.

Lundqvist, U., & Svanström, M. (2008). *Inventering av grundkurser i miljö och hållbar utveckling i Chalmers civilingenjörs- och arkitektprogram.* GMV, Göteborgs miljövetenskapliga centrum. Göteborg: Chalmers tekniska högskola.

Mebratu, D. (1998). Sustainability and sustainable development: historical and conceptual review. *Environment impact assessment review , 18*, 493-520.

Moody, G. L., & Hartel, P. G. (2007). Evaluating an environmental literacy requirement chosen as a methid to produce environmentally literate students. *International Journal of Sustainability in Higher Education , 8* (3), 335-370.

Oxford English Dictionary. (1989). *The Oxford English Dictionary (2nd ed).* Oxford: Oxford University Press.

Saris, W. E., & Gallhofer, I. N. (2007). *Design, evaluation and analysis of questionnaires for survey research.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Schuman, H. (2008). *Method and meaning in polls and surveys.* Cambridge, Massachusetts: Harvard University Press.

Segalàs Coral, J. (2008). *Engineering education for a sustainable future.* Barcelona.

Steinar, K. (1997). *Den kvalitativa forskningsintervjun.* Lund: Stuentlitteratur.

Svanström, M., Lozano-Garcia, J. F., & Rowe, D. (2008). Learning outcomes for sustainable development in higher education. *International Journal of Sustainability in Higher Education , 9* (3), 339-351.

Swedish Ministry of Education and Research. (2003). *Higher Education Ordinance (1993:100) appendix 2, System of Qualifications (SFS 2006:1053).* Stockholm: Ministry of Education and Research.

Swedish Ministry of Education and Research. (2010). *Higher Education Ordinance (1993:100) appendix 2, System of Qualifications (SFS 2006:1053).* Stockholm: Ministry of Education and Research.

Swedish Standards Institute. (2009). *Competence management systems - Requirements.* Stockholm: Swedish Standards Institute.

Wibeck, V. (2000). *Fokusgrupper - om fokuserade gruppintervjuer som undersökningsmetod.* Lund: Studentlitteratur.

Visser, P. S., Krosnick, J. A., Marquette, J., & Curtin, M. (1996). Mail surveys for election forecasting? An evaluation of the Columbus dispatch poll. *Public Opinion Quarterly , 60* (2), 181-227.

World Commission on Environment and Development. (1987). *UN Documents Cooperation Circles - Gathering a Body of Global Agreements.* Retrieved April 20, 2010, from http://www.un-documents.net/ocf-02.htm#I

APPENDICES

Appendix A - List of interviewees

#	Role	Department	Educational background	Sector
1	Chief executive officer	Environment	-	Consultancy
2	Director Sustainability	-	-	Consultancy
3	Business area manager	-	BSc in Engineering	Consultancy and Construction
4	Business area manager Environment	Business area Environment	MSc in Engineering Physics	Consultancy and Construction
5	Senior Vice President Sustainability & /.../	Sustainbility & Green Construction	Scientist - Chemist/Biologist	Consultancy and Construction
6	Strategic manager	Business Development	MSc in Engineering, environment	Energy
7	Human Resource business partner	Nuclear Power	Personnel administrator	Energy
8	Research engineer	Hydro Power Sweden	MSc in Engineering	Energy
9	Human Resource specialist	Human Resources	-	Energy
10	Business Developer	Innovation and Environment	MSc in Engineering Business and Management	Energy
11	Environmental coordinator	Innovation and Environment	MSc in Engineering Business and Management/MSc in Business Economics	Energy
12	Communications	Nuclear Sweden	MSc in Mechanical Engineering	Energy
13	Corporate Responsibility manager	Corporate Responsibility – Human Resources	BSc in work science towards capacity building and organizational development	Energy
14	Recruiter	Corporate Human Resources	MSc in Economics, pedagogy, behavioural science and marketing	Energy
15	Human Resource manager	Climate and Renewables	Psychology/Economics	Energy
16	Senior research engineer	Research & Development	MSc in Technical environmental management, PhD in Water technology	Energy
17	Research engineer	Research & Development	MSc in Environmental and water technologies	Energy
18	Sustainability consultant	Sustainable Development	Econochemistry	Manufacturing
19	Sustainability consultant	Sustainable Development	MSc in Mechanical Engineering and MSc in Industrial Ecology	Manufacturing
20	Manager Sustainable Development	Sustainable Development	MSc in Chemical Engineering, environmental track	Manufacturing
21	Team leader Sustainability	Research, EMF Safety & Sustainability	MSc in Electrical Engineering	Manufacturing
22	Sustainability director	Group Function Technology & Portfolio	MSc in Business Management Engineering	Manufacturing

23	Vice President Environmental affairs	Group Environmental Affairs	-	Manufacturing
24	Sustainability manager	Industrial Division	MSc in Engineering, psychology	Manufacturing
25	Sustainability manager	Corporate Sustainability	Natural Science	Manufacturing
26	Project area manager sustainable production	Technology division	MSc in Chemical Engineering at Chalmers, licenciate	Manufacturing
27	Environmental manager	Strategic Planning	MSc in Chemical Engineering and MSc in Environmental Management and Policy	Manufacturing
28	Head of environmental affairs	Legal	Environmental technician	Manufacturing
29	Head of Advanced /.../ Development	Research & Development	-	Manufacturing
30	Environmental manager	Sustainability	-	Manufacturing
31	Sustainability project manager	-	MSc in Engineering Business and Management	Other sectors
32	Environmental manager	-	MSc in Chemical Engineering	Other sectors
33	Consultant	-	-	Other sectors
34	Senior Advisor Research & Development	-	MSc in Business Management Engineering	Other sectors
35	Research & Development Manager	Defense Analysis	PhD	Other sectors
36	Investigator	-	Social Sciences	Other sectors
37	University researcher	Professor	PhD	Higher education
38	University researcher	Senior lecturer	PhD	Higher education

Appendix B - Semi-structured interview template

Our aim with the discussions is to find out what competences you use today and what competences you believe will be needed within the company 5-10 years from now.

[Company] today

How is [Company]'s work within sustainable development, social responsibility, quality and environment organized today? Is there a separate department working on those issues, or is it integrated into several departments?

Sustainable development can be described as concurrent ecological, economical and social development. Are all three aspects equally important within [Company], or are you emphasizing any of them? Do you see a change in the future where more focus will be placed on any of the three?

General areas in which sustainable development competence can be integrated are for example:

a. Product development

b. R&D

c. Purchase and supply chain

d. Financing department and investments

e. Marketing

How well is sustainable development integrated in these departments at [Company] today? Are there plans or ideas regarding how it will look in 5-10 years from now? Are there other departments than the above mentioned where sustainability is focus on?

Education

When recruiting newly graduated engineers (within all areas at [Company]), do you prefer engineers with profound but narrow or shallow but broad competence (both in general and within the field of sustainable development)?

Are there any certain types of competences lacking today that you are aware of? Is competence within sustainable development seen as competitive advantage or disadvantage when recruiting? Will it change within the next 5-10 years?

Are you as a newly employed engineer ready to work independently or does the company supply the employee with knowledge and tools required to perform and achieve goals (especially when it comes to sustainable development)?

Do you have internal education programs at [Company] which work with the topics of sustainable development, social responsibility, environment and quality? Is [Company] doing anything else to raise the general competence within these areas?

Competences within sustainable development

Are sustainable development issues common knowledge at [Company]? Have all employees enough competence to take responsibility for the entire lifecycle of your projects? Can all employees see the connections between their own work and sustainability?

Is it preferable to achieve front edge competence amongst few, raise common knowledge amongst many or both?

Do [Company] employees have a systems perspective when it comes to these issues?

Communication

Is there a general acceptance for sustainable development amongst employees, managers and the board of directors? And how do the [Company] employees perceive sustainable development issues; as diffuse or clear?

How does the communication regarding sustainable development work with the general employee at the company? Would a higher general knowledge amongst the employees improve the communication regarding sustainable development, or is it more important with other channels of information?

[Company] acknowledges sustainable development but is there a general acceptance for sustainable development amongst the employees?

The present and the future

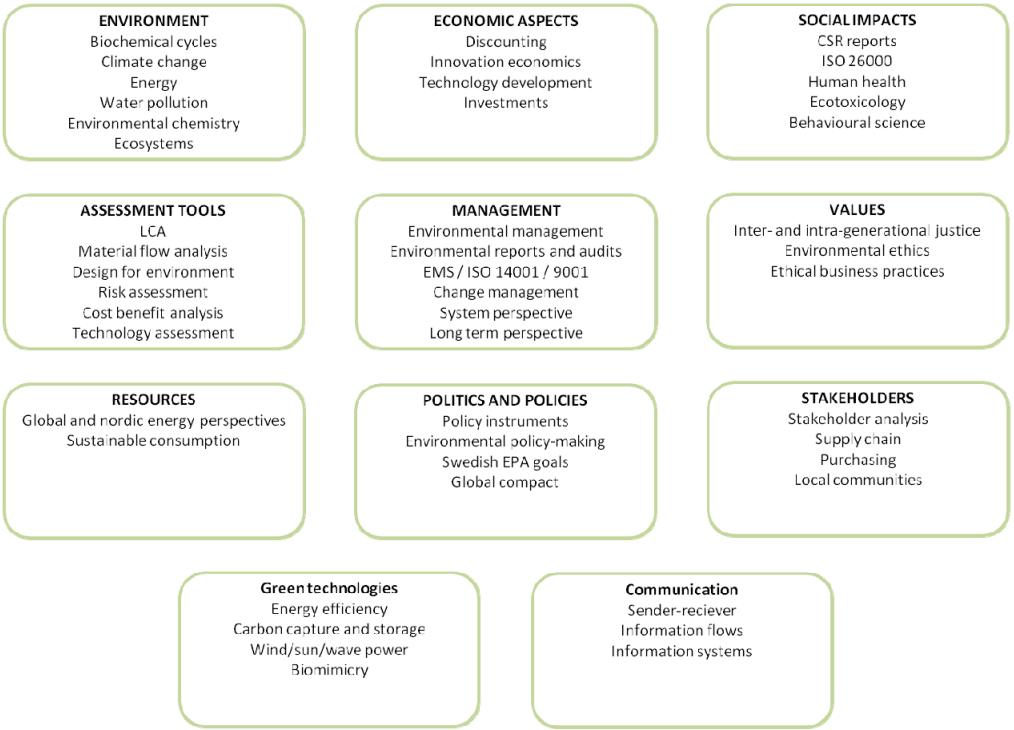
What do you think [Company] will work with, within the concept of sustainable development, within the next 5-10 years?

How large part/percentage of the company operations is within or connected to sustainable development today? How large influences will the concept have on the company operations within the next 5-10 years?

Are there any long-term goals for sustainable development and how do they relate to other company specific long-term goals? Do they act on the same time scale, or do they use different time scales?

Competences available at Chalmers today

Are there any aspects within these eleven areas which [Company] tend to focus more or less on? Is a higher or lower competence within any of these areas needed at [Company]?



Appendix C - Letter to company

Behovsanalys av ingenjörskompetens inom hållbar utveckling

Hej [Namn],

Här kommer lite mer bakgrund om exjobbet som beskriver de viktigaste delarna i projektet och vad kontakten mellan oss och [Företag] kan ge.

Bakgrund

Chalmers vision, *Chalmers – för en hållbar framtid*, visar att Chalmers arbetar hårt med att utveckla hållbara lösningar på dagens och framtidens problem. Som en del av detta har Chalmers lärandecentrum skapats med målet att utveckla lärandet för hållbar utveckling på Chalmers.

Vi har identifierat att Chalmers utbildningar inte alltid återspeglar de kompetensbehov företag och organisationer har inom miljö och hållbar utveckling. För att komma tillrätta med detta och på så sätt utbilda framtidens ingenjörer inom rätt områden, kommer vi inom vårt exjobb att föra en dialog med ett tjugotal stora internationella företag belägna i Sverige, varav [Företag] är ett, där vi vet att det finns ett behov av ingenjörer som har kunskaper inom miljö och hållbar utveckling.

Genomförande

Genom att intervjua ett antal miljöchefer, gruppchefer, HR-ansvariga, ingenjörer m.m. som alla på något sätt kommer i kontakt med kompetensbehov inom miljö och hållbar utveckling på sina respektive företag, så vill vi gemensamt försöka få fram vilka kunskaper som efterfrågas inom företagen, samt även se vilka kunskaper som saknas, eller vilka som behöver förstärkas. På det viset vill vi komma åt vilka kompetenser som krävs för att arbeta inom företagen just nu, men också för att långsiktigt arbeta för att koppla Chalmers utbildningar till de kompetensbehov som kommer att finnas på arbetsmarknaden i framtiden.

Resultaten från dessa intervjuer kommer sedan att ligga till grund för en enkätundersökning där vi vill klarlägga behoven inom medelstora till stora företag i Sverige för att ge en ännu tydligare bild av vilka kompetensbehov som finns på företag runt om i Sverige.

Vad vi behöver för hjälp

Vi önskar att träffa dig på [Företag] som arbetar med företagets arbete rörande [miljö/sociala frågor/hållbarhet], men gärna även några av dina kollegor som inte arbetar direkt med detta område. Intervjun pågår under cirka 1 timme där vi kan diskutera ovanstående frågeställningar ur [Företag]s perspektiv.

Vad [Företag] får ut av ett samarbete

Genom att hjälpa oss kommer du och [Företag] bidra till att utveckla undervisningen på Chalmers inom miljö och hållbar utveckling. Genom ditt och eventuellt dina medarbetares engagemang kommer ni kunna ge idéer om i vilken riktning Chalmers ska tänka i form av utbildning och på det sättet säkra att ni i framtiden kommer få medarbetare som bättre motsvarar de kompetensbehov ni har inom miljö och hållbar utveckling.

Med vänliga hälsningar,

Anna Priem & Andreas Hanning

Appendix D - List of participating companies and organizations

Interviews

- AB Volvo
- ABB
- Akzo Nobel
- DHL
- Electrolux
- E.ON
- Ericsson
- Hifab
- Husqvarna
- IKEA
- Scania
- Skanska
- SKF
- Sweco
- Vattenfall
- ÅF

Focus group discussion

- The Natural Step (Det Naturliga Steget)
- FOI, Swedish Defence Research Agency (Totalförsvarets forskningsinstitut)
- Swedish National Agency for Higher Education (Högskoleverket)
- The Association of Swedish Engineering Industries (Teknikföretagen)

Individual meetings or electronic conversations

- Delft University of Technology (TUDelft)
- Chalmers University of Technology
- Blekinge Institute of Technology

Additionally, the authors also interviewed The Swedish Association of Graduate Engineers (Sveriges Ingenjörer) regarding their alumni survey.

Appendix E - Course content categories

Assessment tools	Economic aspects	Environment	Green technologies	Management
				Innovation economics / Technology development (including a historical perspective)
Design for Environment (DfE)	SD Decoupling	Exergy	HVAC systems, applications, equipment	
Environmental impact assessment (EIA)	Discounting	Entrophy assessment	Energy supply systems (HVAC interaction wth international and national systems)	Environmental Management
Life cycle perspective	Subsidising technologies	Energy balances (incl. Earth energy conversion and balance)	Commissioning/energy management (usage, economic performance etc)	Environmental Management Systems (EMS)
LCA	Technological change	Ecosystems	Energy balance (of conditioned spaces)	Environmental Accounting
BASF assessment tools	SD - rebound effect	Radiation	Indoor climate (control)	Environmental Reports and Audits
Substance flow analysis (SFA)	SD - Globalization	Environmental chemistry (radicals, photochemical reactions, pH, pE, entalhpy etc)	Energy efficiency	Supply Chain Management and Audits
Total material requirement (TMR)	SD - world population	Atmospheric pollution incl measurements	Future energy technologies (eg CCS)	Corporate strategic tools for environmental assessment (MET-matric, Eco Strategy Wheel, Functional Analysis, Dismantling analysis, Design for recycling, functional analysis, market analysis, environmental effect analysis, environmental QFD)

Assessment tools	Economic aspects	Environment	Green technologies	Management
Material input per service (MIPS)	Technological options and economic and environmental impact from energy conversion technologies	The atmospheric processes - climate system	Passive houses	Commissioning/energy management (usage, economic performance etc)
Material flow analysis (MFA)	Technological change	Atmospheric reactions (C, N, S, smog, aerosols, ozone, chemical processes and turnover of pollutants)	Sustainable building	CSR - corporate social responsibility
Sustainability indicators (SI)	Innovation economics / Technology development (including a historical perspective)	The hydrosphere from an environmental change perspective (water cycles, fluxes, reserviours, processes, resources)	Heat and electric power generation (existing and developing technologies incl. CHP)	
Cost Benefit Analysis (CBA)	Environmental Management	Water pollution,WP management and WP measurements	Performance and design of thermal power plants	
Industrial Ecology Concept	Corporate strategic tools for environmental assessment (MET-matric, Eco Strategy Wheel, Functional Analysis, Dismantling analysis, Design for recycling, functional analysis, market analysis, environmental effect analysis, environmental QFD)	Biochemical cycles (Carbon cycle)	Emission control / Carbon capture and storage technologies (CCS)	
Dematerialization /Transmaterialization / Substitution		Biochemical cycles (N, S, P, M+)	Technological options and economic and environmental impact from energy conversion technologies	

Assessment tools	Economic aspects	Environment	Green technologies	Management
Technology assessment (TA)		Lithospheric system - Acidification	Thermodynamics of power generation	
Input-Output Analysis (I-O)		Lithospheric system - Eutrophication	Photovoltaics	
Multi-Criteria Analysis (MCA)		Greenhouse gases an/or other air pollution chemicals	Hybrid electrical vehicles	
Stakeholder Analysis		Greenhouse gas effects	Green fuels for transportation (biodiesel, DME, Ethanol, hydrogen, biomethande, electricity)	
Environmental Management Systems (EMS)		Greenhouse gas processes, feedbacks, modelling, GWP	Recycling methods	
Environmental Accounting		Ecotoxicology and human health effects	Smart grids	
Environmental Marketing (ECO-labelling)		Utilization of ecosystems and effects of disturbing biological systems	Green IT	
Environmental Reports and Audits		Climate change - effects lithosphere (soil properties, pedosphere, weathering, degradation)	Innovation economics / Technology development (including a historical perspective)	
Impact Analysis			Solar energy	
Supply Chain Management and Audits		SD - biodiversity	Bioenergy technologies / Biogas system	
Carbon footprint		SD - water scarcity	Solar energy	

Assessment tools	Economic aspects	Environment	Green technologies	Management
		Environmental pollution in transportation systems	Hydroelectrical power	
Ecological footprint		CO_2 emissions	Wind power	
I= imup / I=pat				
Corporate strategic tools for environmental assessment (MET-matric, Eco Strategy Wheel, Functional Analysis, Dismantling analysis, Design for recycling, functional analysis, market analysis, environmental effect analysis, environmental QFD)				
		Engineering Geology	Wave energy	
Environmental Design		Drinking water engineering	Energy storage	
Material selection from an environmental perspective		Hazardous waste, radioactive waste	Biorefinery	
Environmental Risk Assessment (ERA)		Waste treatement methods		
Risk Assessment (RA)		SD - water scarcity		
What-if procedure		Societal material flows		
Hazard and operability analysis (HAZOP)		Ecological footprint		
Failure mode and effects analysis (FMEA)		Environmental Risk Assessment (ERA)		
Variation mode and effects analysis (VMEA)		Societal waste flows (solid waste, waste water)		
Cause-effect analysis (CEA)		Landfilling		
Fault Tree Analysis (FTA)		Biomagnification of toxins		
Event Tree Analysis (ETA)				
Probability Safety Assessment (PSA)				

Assessment tools	Economic aspects	Environment	Green technologies	Management
Understanding and calculating environmental pollution, emissions and spillage in RA				
Energy simulation and optimisation modelling tools (EBSILON, MARTES, LEAP, LP)				
Cause-effect chains for environmental impacts				
Skills/tools/methods for assessing for SD				
Strategic Environmental assessment (SEA)				
Precautionary Principle (PP)				
As Low As Reasonably Practical (ALARP)				
Sensitivity analysis(Web-HIPRE)				
Spatial Analysis and Decision Assistance (SADA)				
Monte Carlo simulations				
Uncertainty analysis (Crystal Ball)				
Human Health Risk Assessment				
MKB - environmental concequence description?				
Systems approach				
DPSIR				
SD - backcasting				
Ecological rucksack				

Assessment tools	Economic aspects	Environment	Green technologies	Management
SD - the Natural Step				
SD - cradle to cradle				
SD - PDCA cycle				
SD - Ecodesign				
SD - Biomimicry				
MET-matrix				
Entrophy assessment				
Energy balances (incl. Earth energy conversion and balance)				
SD - the four principles				

Politics and policies	Resources	Social impacts	Stakeholders	Values
UNFCCC and Kyoto Protocol	SD Sustainable consumption	SD - Globalization	Stakeholder Analysis	Inter and intra generational justice
Need for environmental policy-making	SD - agriculture, food, bioenergy, land use	SD - world population	Environmental Management	Environmental Ethics
Policy Instruments	SD - forestry and forest	Health and environmental effects from electromagnetic fields	Environmental Marketing (ECO-labelling)	Dichotomies
Agenda 21	Societal material flows	Health effects from chemical substances	Energy consumers	SD - definitions (i.e. Brundtland)
The Swedish environmental goals (SwedishEPA)	Fossil fuels	CSR - corporate social responsibility	Environmental Management Systems (EMS)	Ethics (regular and not purely environmental ethics)
Legislature concerning environmental building	Nordic energy perspective	Biomagnification of toxins	Environmental Reports and Audits	SD - the four principles
Energy policy tools	Global energy perspective	Ecotoxicology and human health effects	Supply Chain Management and Audits	SD - need for dietary changes (i.e. shift towards vegetarianism)

Politics and policies	Resources	Social impacts	Stakeholders	Values
Environmental rules and regulations	Nuclear power	Climate change - effects		CSR - corporate social responsibility
MKB - environmental concequence description?	Solar energy	SD Sustainable consumption		
SD - Globalization	Bioenergy technologies / Biogas system	SD - agriculture, food, bioenergy, land use		
	Solar energy	Impact Analysis		
	Hydroelectrical power	Risk Assessment (RA)		
	Energy consumers	Human Health Risk Assessment		

Politics and policies	Resources	Social impacts	Stakeholders	Values
	Local and regional energy systems (DH)	SD - water scarcity		
	Wind power			
	Fusion Power			
	Wave energy			
	Energy storage			
	Biorefinery			
	Societal waste flows (solid waste, waste water)			
	Landfilling			
	Swedish energy perspective			
	SD - food security Water pollution,WP management and WP measurements			

Politics and policies	Resources	Social impacts	Stakeholders	Values
	Utilization of ecosystems and effects of disturbing biological systems SD - biodiversity			
	Green fuels for transportation (biodiesel, DME, Ethanol, hydrogen, biomethande, electricity) Ecological rucksack			

Appendix F - List of analyzed courses in the inventory.

Course code	Course	Credit units	Program	Mandatory/optional/recommended
FFR166	Science of environmental change	7.5	Industrial Ecology	Mandatory
FFR160	Sustainable development	7.5	Industrial Ecology	Mandatory
ENM015	Technical change and the environment	7.5	Industrial Ecology	Mandatory
UNA016	Environmental Policy Instruments	7.5	Industrial Ecology	Mandatory
ENM021	Applied Industrial Ecology	7.5	Industrial Ecology	Mandatory
VMI035	Environmental management	7.5	Industrial Ecology	Mandatory
VTM081	Life Cycle Assessment	7.5	Industrial Ecology	Recommended
MPM090	Environmentally adapted product development and manufacturing	7.5	Industrial Ecology	Recommended
IPE061	Risk management and safety	7.5	Industrial Ecology	Optional
TEK285	Logistics and Supply Chain Management	7.5	Industrial Ecology	Optional
ENM045	Heating, ventilation and air conditioning system engineering	7.5	Sustainable Energy Systems	Mandatory
ENM046	Heating, ventilation and air conditioning system engineering	7.5	Industrial Ecology	Optional
FFR170	Sustainable energy futures	7.5	Sustainable Energy Systems	Mandatory
FFR171	Sustainable energy futures	7.5	Industrial Ecology	Recommended
MEN120	Heat and power systems engineering	7.5	Sustainable Energy Systems	Mandatory
MEN115	Energy systems modelling and planning	7.5	Sustainable Energy Systems	Mandatory
ENM095	Sustainable power production and transportation	7.5	Sustainable Energy Systems	Optional
ENM035	Assessing sustainability -assignments	7.5	Environmental Measurments and Assessments	Mandatory
VMI010	Environmental systems analysis	7.5	Environmental Measurments and Assessments	Mandatory
EVMI010	Environmental systems analysis	7.5	Geo and Water Engineering	Mandatory
BOM060	Environmental risk assessment in engineering	7.5	Environmental Measurments and Assessments	Mandatory
KMG005	Atmospheric measurements 1	7.5	Environmental Measurments and Assessments	Mandatory
KMG065	Atmospheric measurements 2	7.5	Environmental Measurments and Assessments	Optional
ENM040	Strategic environmental assessment	7.5	Environmental Measurments and Assessments	Recommended
ENM090	Environmental impact assessment	7.5	Environmental Measurments and Assessments	Recommended
VTM051	Environmental analysis of water	7.5	Environmental Measurments and Assessments	Optional
BOM125	Risk control in engineering	7.5	Geo and Water Engineering	Optional

Course code	Course	Credit units	Program	Mandatory/optional/recommended
VGE022	Engineering geology	7.5	Geo and Water Engineering	Mandatory
BOM075	Drinking water engineering	7.5	Geo and Water Engineering	Mandatory
KBT140	Global chemical sustainability	7.5	Innovative and Sustainable Chemical Engineering	Recommended
KVM013	Industrial energy systems	7.5	Innovative and Sustainable Chemical Engineering	Recommended
KBT145	Biorefinery	7.5	Innovative and Sustainable Chemical Engineering	Recommended
KKM067	Ecodesign	7.5	Innovative and Sustainable Chemical Engineering	Recommended
KTK061	Pollution prevention	7.5	Innovative and Sustainable Chemical Engineering	Optional
KBT135	Waste management	7.5	Innovative and Sustainable Chemical Engineering	Recommended
KKM022	Ecology for engineers	7.5	Innovative and Sustainable Chemical Engineering	Recommended
ENM011	Environmental systems	7.5	Automation and mechatronics engineering	Mandatory
KOO041	Chemistry with biochemistry	1.5 (21.5)	Bioengineering	Mandatory
KKM080	Biochemical environmental science	4.5	Bioengineering	Mandatory
KKR090	Bioreaction engineering	1.5 (9)	Bioengineering	Mandatory
KSK055	Chemical engineering, environment and society	4.5	Chemical engineering	Mandatory
KVM033	Heat and power technology	6	Chemical engineering	Mandatory
KKM051	Chemical environmental science	4.5	Chemical engineering	Mandatory
KOO081	Chemistry	18	Chemical engineering with engineering physics	Mandatory
VMI041	Environmental and resource analysis for sustainable development	7.5	Civil engineering	Mandatory
FFR101	Sustainable use of resources	7.5	Computer science and engineering	Mandatory
EEK136	Environmental and power technology	7.5	Electrical engineering	Mandatory
TIF190	Physics for engineers 1: physics for sustainable development	7.5	Engineering mathematics	Mandatory
TIF075	Environmental physics	4.5	Engineering physics	Mandatory
PPU065	Environmental technology and sustainable development	7.5	Industrial design engineering	Mandatory
ENM110	Environmental and energy systems	7.5	Mechanical engineering	Mandatory
ITS022	Technology for a global sustainable society	7.5	Software engineering	Mandatory

Course code	Course	Credit units	Program	Mandatory/optional/recommended
ARK205	Building and climate	7.5	Architecture and engineering	Mandatory
ENM085	Architecture and systems design for sustainable development	15	Architecture and engineering	Mandatory
IAR087	Industrial organisations development	15	Industrial engineering and management	Mandatory
IKA096	Management information systems	7.5	Industrial engineering and management	Mandatory
TEKX04	Bachelor's thesis in technology management and economics	15	Industrial engineering and management	Mandatory
MMF172	Introduction to mechanical engineering	3	Mechanical engineering	Mandatory
MTF041	Thermodynamics	4.5	Mechanical engineering	Mandatory
TEK060	Industrial production and organization	6	Mechanical engineering	Mandatory
IEK102	Engineering economics	4.5	Mechanical engineering	Mandatory
KBT200	Products and processes in a sustainable society	7.5	Chemical engineering	Mandatory
LSP310	Communication and professional development	7.5	Software engineering	Mandatory
MVE345	Environment and mathematical modelling	7.5	Engineering mathematics	Mandatory
KMB040	Metabolism and applied microbiology	4.5	Bioengineering	Mandatory
MPP085	Introduction to automation and mechatronic engineering	7.5	Automation and mechatronics engineering	Mandatory
MMK072	Materials and manufacturing technology	7.5	Automation and mechatronics engineering	Mandatory
SSY046	Systems engineering	7.5	Automation and mechatronics engineering	Mandatory
IAR072	Production management	7.5	Industrial engineering and management	Mandatory
ITR233	Logistics I	7.5	Industrial engineering and management	Mandatory

Appendix G - Focus group discussion guide

Fokusgrupp om samhällsbehovet av kompetens inom hållbar utveckling

Till denna fokusgrupp har vi samlat personer från Det Naturliga Steget, IVL Svenska Miljöinstitutet, Utbildningsdepartementet och FOI, samt Teknikföretagen. Det vi vill utvinna ur diskussionen är vilka behov samhället kommer att ha inom hållbar utveckling inom 5-10 år. Detta behov kommer i sin tur påverka vilka kompetenser som kommer att krävas inom hållbar utveckling.

Hållbar utveckling brukar definieras som när man uppnår miljömässig, ekonomisk och social hållbar utveckling. Det betyder att vi är intresserade av allt det som ni själva anser att ni relaterar till hållbar utveckling.

Samhällets behov

Vad finns det för behov inom hållbar utveckling i dagens samhälle?

Idag finns det ett stort miljömedvetande i samhället jämfört med för några år sedan. Kommer detta medvetande att öka och i sådana fall, hur kommer det att påverka företagens inställning?

Det finns också ett stort fokus på energifrågor i dagens samhälle. Tror ni att detta kommer att öka, eller är det andra områden inom hållbarhet som kommer bli viktiga i framtiden. Om så är fallet, vilka skulle dessa områden kunna vara?

Idag är det vissa marknader som tydligt arbetar med hållbar utveckling. Kommer det inom 5-10 år att finnas behov av hållbar utveckling inom fler områden är de som arbetar med det idag?

Kommer det att bli ett ökat fokus på miljömedvetenhet inom fler marknader och i alla led inom olika leverantörskejdor?

Kommer ett ökat fokus på miljö också innebära ett ökat fokus på andra hållbarhetsfrågor, såsom det bredare begreppet Corporate Social Responsibility (CSR)?

Kommer energifrågor tillsammans med miljö fortsätta att vara i centrum, eller kommer social hållbarhet bli viktigare för kunderna i framtiden?

Kommer samhällsmedborgarna behöva förändras i framtiden och hur kommer det i sådana fall påverka företagen?

Samhället har ett behov av service och tjänster som servas av företagen (m.fl.). Kommer dessa behov att förändras i framtiden? Vilka kompetenser kommer företagen behöva för att möta detta?

Hurdana samhällsmedborgare kommer företagen att behöva vara (Corporate Citizens)? Kommer samhället kräva mer av företagen?

Företagens påtryckande roll

Företagen svarar ofta mot samhällets behov, men hur anser ni att företagen borde uppföra sig gentemot samhället i övrigt? Ska företagen försöka forma samhället mer hållbart, eller ska bara göra det som samhället i övrigt vill att de ska göra?

Utbildarnas påtryckande roll

Genom att välja vilka utbildningar som ges och vilket innehåll de får så kan universitet och högskolor styra vilka kompetenser som kommer ut i samhället. Är detta en roll som högskolorna måste bli tydligare med?

Ingenjörens roll i samhället

Vilket ansvar har ingenjörer för att göra utvecklingen hållbar?

Är tekniska lösningar ett verktyg eller en drivkraft för att skapa ett hållbart samhälle? Eller är det både och?

Vems ansvar?

Vems ansvar kommer det att vara att se till att vi får en hållbar utveckling i samhället?

Appendix H – Authors' alumni survey

Enkät kring kompetensbehov inom hållbar utveckling

Tack för att du tar dig tid att fylla i denna enkät.

Enkäten är skickad till dig som är alumn från Chalmers och är en uppföljning på alumnienkäten som du fick skickad till dig förra året. Enkäten ska ses som en fördjupning inom kompetensbehov inom hållbar utveckling.

Samtidigt som enkäten är en uppföljning på alumnienkäten, så är den också en del av ett exjobb som genomförs på Chalmers lärandecentrum.
Tack för att du tar dig tid att fylla i denna enkät!

Dina resultat är värdefulla för Chalmers och för vidareutvecklingen av Chalmers utbildningar. Chalmers värdesätter att du tar dig tid att bidra med din kunskap om din utbildning och hur den har påverkat dig i ditt yrkesliv.

Den här enkäten innehåller 26 frågor

Bakgrundsfrågor

Del 1 av 4 - Bakgrundsfrågor. Ifall du inte är anställd för tillfället kan du ange hur det såg ut på din tidigare arbetsplats.

1 Vilken typ av organisation arbetar du inom? *

Välj **bara en** av följande:

- ○ Privat företag
- ○ Statlig verksamhet/landsting/kommunal verksamhet
- ○ Högskola/universitet

2 Antal anställda? *

Välj **bara en** av följande:

- ○ 1-499
- ○ 500-999
- ○ 1000-3999
- ○ 4000-7999
- ○ 8000-11999
- ○ 12000–>

En ungefärlig siffra räcker. Ifall du jobbar i en internationell stor organisation, men med få anställda i Sverige, ange då antalet anställda i Sverige.

3 Vilken typ av ansvar har du? *

Välj **alla** som stämmer:

- ☐ Personalansvar
- ☐ Produktions/processansvar
- ☐ Projekledaransvar
- ☐ Ekonomiskt ansvar
- ☐ Säljansvar
- ☐ Teknisk specialist/expert
- ☐ Utvecklings-/konstruktionsansvar
- ☐ Inköpsansvar
- ☐ Forskning och utvecklingsansvar
- ☐ Miljöansvar
- ☐ Övrigt

Företaget

Del 2 av 4 - Frågor kring hur hållbarhetsarbetet ser ut på det företag du arbetar på. Ifall du inte är anställ för tillfället kan du svara på hur det såg ut på din senaste arbetsplats.

4 Mitt företag tar ansvar för... *

Välj **bara en** av följande:

- ○ ... miljöfrågor som rör vår verksamhet.
- ○ ... sociala frågor som berör vår verksamhet.
- ○ ... miljöfrågor och sociala frågor som berör vår verksamhet.
- ○ ... inget av ovanstående.

5 Välj det alternativ som stämmer överens bäst. *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
Det finns en funktion/avdelning inom företaget som ansvarar för alla frågor som rör hållbar utveckling.	○	○	○
Kan du relatera ditt företags hållbarhetsmål till ditt arbete?	○	○	○
Jag ansvarar själv för hållbarhetsaspekter som rör mitt dagliga arbete.	○	○	○

6 Välj det alternativ som passar bäst. *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
Jag har en företagsledning som tydligt stödjer arbete inom hållbar utveckling.	○	○	○
Jag uppmuntras av mitt företag att se till en eller flera av hållbarhetsaspekterna i mitt dagliga arbete.	○	○	○

7 Vad finns det för bakomliggande drivkrafter som gör att företag idag arbetar med hållbar utveckling?

Välj **alla** som stämmer:

- ☐ Ekonomisk lönsamhet
- ☐ Vara en god samhällsmedborgare
- ☐ Värna om naturen
- ☐ Stärka företagets varumärke och goda rykte
- ☐ Jämställdhet mellan den rika och fattiga världen
- ☐ Eliminera företagets risker
- ☐ Skapa trygghet för framtida generationer
- ☐ Reducera företagets kostnader
- ☐ Möta kundernas efterfrågan
- ☐ Bidra till det lokala samhället

8 Vilka är de viktigaste bakomliggande drivkrafterna som gör att företag idag arbetar med hållbar utveckling? (Välj så många du tycker passar)

Rangordna, genom att sätta ett nummer i varje ruta, från 1 till 10

- ☐ Ekonomisk lönsamhet
- ☐ Vara en god samhällsmedborgare
- ☐ Värna om naturen
- ☐ Stärka företagets varumärke och goda rykte
- ☐ Jämställdhet mellan den rika och fattiga världen
- ☐ Eliminera företagets risker
- ☐ Skapa trygghet för framtida generationer
- ☐ Reducera företagets kostnader
- ☐ Möta kundernas efterfrågan
- ☐ Bidra till det lokala samhället

Utbildningens betydelse

Del 3 av 4 - Utbildningens betydelse.

9 Hur/på vilket sätt har du kommit i kontakt med området hållbar utveckling i din Chalmersutbildning? *

Välj **alla** som stämmer:

- [ ] Jag stötte på det som mindre inslag i någon eller några kurser.
- [ ] Jag gick en grundkurs i miljö och hållbar utveckling.
- [ ] Jag läste en inriktning (masterprogram) inom miljö och hållbar utveckling.
- [ ] Jag kom ej i kontakt med området hållbar utveckling under min Chalmerstid.

10 Jag upplever att utbildningen på Chalmers har utrustat mig med kunskaper och färdigheter så att... *

Välj det korrekta svaret för varje punkt:

	1 = Stämmer *inte alls*	2	3	4	5	6	7	8	9	10 = Stämmer *mycket väl*	Vet ej/ej applicerbart
... jag har god insikt i vad begreppet "hållbar utveckling" innebär.	○	○	○	○	○	○	○	○	○	○	○
... jag har en god förståelse och färdigheter i hur jag kan bidra till utvecklingen av miljö och hållbarhet.	○	○	○	○	○	○	○	○	○	○	○
... jag kan argumentera för varför miljö-och hållbarhetsfrågor är viktiga ur ett affärsperspektiv.	○	○	○	○	○	○	○	○	○	○	○
... jag upplever att jag saknar kunskaper för att praktiskt kunna beakta hållbarhetsaspekter i mitt arbete.	○	○	○	○	○	○	○	○	○	○	○

11 Jag upplever att jag genom Chalmers utbildning har tillägnat mig ämneskunskaper i form av... *

Välj det korrekta svaret för varje punkt:

	1 = *Mycket begränsade* kunskaper	2	3	4	5	6	7	8	9	10 = Mycket *goda* kunskaper
...kunskaper i miljö och hållbar utveckling.	○	○	○	○	○	○	○	○	○	○

12 Jag upplever att jag genom Chalmers utbildning har tillägnat mig ett arbets- och tankesätt som gett mig... *

Välj det korrekta svaret för varje punkt:

	1 = Mycket *begränsad* förmåga	2	3	4	5	6	7	8	9	10 = Mycket *god* förmåga
...insikt i teknikens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används.	○	○	○	○	○	○	○	○	○	○
...förmåga att göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter.	○	○	○	○	○	○	○	○	○	○
...förmåga att kommunicera muntligt och skriftligt inom hållbar utveckling.	○	○	○	○	○	○	○	○	○	○

13 Hur bedömer du att utbildningen har förberett dig för ditt nuvarande arbete när det gäller att... *

Välj det korrekta svaret för varje punkt:

	1 = Mycket *dåligt*	2	3	4	5	6	7	8	9	10 = Mycket *bra*
...utforma produkter och teknik med hänsyn till människors behov och samhällets mål för hållbar utveckling?	○	○	○	○	○	○	○	○	○	○

14 Finns det... *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
... företagsutbildning som relaterar till hållbar utveckling på det företag du arbetar på?	○	○	○

15 Du svarade att det finns företagsutbildningar som relaterar till hållbar utveckling på ditt företag. *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Ja' på fråga '14 [U7]' (Finns det... (... företagsutbildning som relaterar till hållbar utveckling på det företag du arbetar på?))

Välj bara en av följande:

- ○ **Jag *har* gått en företagsutbildning som relaterar till hållbar utveckling.**
- ○ **Jag *har inte* gått en företagsutbildning som relaterar till hållbar utveckling.**

16 Finns det... *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
... ett behov av att ha företagsutbildningar som relaterar till hållbar utveckling?	○	○	○

17 Du svarade att du har gått en företagsutbildning som relaterar till hållbar utveckling.
Var den kursen... *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Jag *har* gått en företagsutbildning som relaterar till hållbar utveckling.' på fråga '15 [U8]' (Du svarade att det finns företagsutbildningar som relaterar till hållbar utveckling på ditt företag.)

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
... obligatorisk?	○	○	○

18 Jag upplever att jag hade behövt få bättre kunskap inom följande områden från min utbildning på Chalmers... *

Välj alla som stämmer:

- [ ] Miljö: Förståelse för hur naturen fungerar t ex klimatförändringar, ekosystem, miljökemi, föroreningar och energi.
- [ ] Ekonomi: Förståelse för t ex diskontering, investering, innovationsekonomi och teknisk utveckling.
- [ ] Social påverkan: Förståelse för företags arbete gentemot samhället t ex Corporate Social Responsibility, ekotoxikologi, människohälsa, beteendevetenskap.
- [ ] Utvärderingsverktyg: Olika verktyg för att arbeta miljövänligt eller utvärdera miljö- eller social påverkan t ex LCA, Design for environment, risk assessments och cost benefit analysis.
- [ ] Ledning: Förståelse för t ex miljöledningssystem, hållbarhetsrapporter och nyckeltal inom hållbarhet.
- [ ] Värderingar: Förståelse för företagsetik kring hållbarhetsfrågor t ex rättviseaspekter inom miljö och resurshantering, rättvisa mellan generationer och rättvisa mellan industri- och utvecklingsländer.
- [ ] Resurser: Resursanvändning samt kännedom om vilka resurser som kan vara kritiska i framtiden.
- [ ] Lagar och förordningar: Kännedom om nutida och framtida lagar och förordningar som rör hållbar utveckling och hur de påverkar företaget.
- [ ] Intressenter: Förståelse för företagets intressenter i hela leverantörskedjan och ut till slutanvändare.
- [ ] Nya teknologier: Vetenskap kring nya teknologier som anses vara miljövänligare än befintliga t ex vindkraft och koldioxidlagring.
- [ ] Kommunikation: Bättre förståelse för ämnet hållbar utveckling för att förstå hur det kommuniceras.
- [ ] Jag upplever att jag fick tillräckligt god kunskap inom de ovanstående områdena från min utbildning på Chalmers.
- [ ] Jag upplever att jag inte fick tillräckligt god kunskap inom de ovanstående områdena, men jag har heller inget behov av större kunskap inom dem.

19 Rangordna de viktigaste kunskapskategorierna som behövs för att arbeta med hållbar utveckling.

Rangordna, genom att sätta ett nummer i varje ruta, från 1 till 11

- [ ] Miljö: Förståelse för hur naturen fungerar t ex klimatförändringar, ekosystem, miljökemi, föroreningar och energi.
- [ ] Ekonomi: Förståelse för t ex diskontering, investering, innovationsekonomi och teknisk utveckling.
- [ ] Social påverkan: Förståelse för företags arbete gentemot samhället t ex Corporate Social Responsibility, ekotoxikologi, människohälsa, beteendevetenskap.
- [ ] Utvärderingsverktyg: Olika verktyg för att arbeta miljövänligt eller utvärdera miljö- eller social påverkan t ex LCA, Design for environment, risk assessments och cost benefit analysis.
- [ ] Ledning: Förståelse för t ex miljöledningssystem, hållbarhetsrapporter och nyckeltal inom hållbarhet.
- [ ] Värderingar: Förståelse för företagsetik kring hållbarhetsfrågor t ex rättviseaspekter inom miljö och resurshantering, rättvisa mellan generationer och rättvisa mellan industri- och utvecklingsländer.
- [ ] Resurser: Resursanvändning samt kännedom om vilka resurser som kan vara kritiska i framtiden.
- [ ] Lagar och förordningar: Kännedom om nutida och framtida lagar och förordningar som rör hållbar utveckling och hur de påverkar företaget.
- [ ] Intressenter: Förståelse för företagets intressenter i hela leverantörskedjan och ut till slutanvändare.
- [ ] Nya teknologier: Vetenskap kring nya teknologier som anses vara miljövänligare än befintliga t ex vindkraft och koldioxidlagring.
- [ ] Kommunikation: Bättre förståelse för ämnet hållbar utveckling för att förstå hur det kommuniceras.

Ditt arbete idag

Del 4 av 4 - Frågor kring ditt arbete idag och hur du möter hållbarhetsfrågor i det. Ifall du inte är anställd idag kan du ange hur det såg ut på din förra arbetsplats.

20 Hur ofta möter du hållbarhetsfrågor i ditt arbete? *

Välj bara en av följande:

- ○ **Dagligen**
- ○ **Ibland**
- ○ **Sällan**
- ○ **Aldrig**

21 Har du vidareutbildat dig inom området hållbar utveckling? *

Välj alla som stämmer:

- ☐ **Ja, genom kurs(er) och utbildningar m.m. bekostade av min arbetsgivare.**
- ☐ **Ja, genom praktiska projekt.**
- ☐ **Ja, genom forskning.**
- ☐ **Nej, jag har inte vidareutbildat mig inom området.**

Det är möjligt att välja flera svarsalternativ.

22 Hur väl stämmer följande påstående in på ditt arbete, ditt företag, eller den bransch du är verksam inom? *

Välj det korrekta svaret för varje punkt:

	1 = Stämmer *inte alls*	2	3	4	5	6	7	8	9	10 = Stämmer *mycket väl*	Vet ej/ej applicerbart
Miljö och hållbarhetsfrågor blir allt viktigare i den bransch som mitt företag verkar inom (exempelvis genom hårdare lagstiftning, nya marknader, konkurrenters erbjudanden, etc.)	○	○	○	○	○	○	○	○	○	○	○
På mitt jobb är miljö- och hållbar utvecklingsfrågor en viktig del i produktutvecklingen.	○	○	○	○	○	○	○	○	○	○	○
Jag upplever det som att företagets intresse för miljö- och hållbarhetsfrågor har ökat det senaste året (eller åren).	○	○	○	○	○	○	○	○	○	○	○
I mitt arbete förväntas jag ta ställning till miljö- och hållbarhetsfrågor.	○	○	○	○	○	○	○	○	○	○	○
Jag tror att miljö- och hållbarhetsfrågor kommer att bli viktigare för min arbetsgivare i framtiden.	○	○	○	○	○	○	○	○	○	○	○

23 Har du tillräcklig kunskap för att... *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
...ta beslut utifrån ett hållbarhetsperspektiv?	○	○	○

24 Om du har arbetat med hållbarhetsfrågor på ditt företag, fick du då kunskapen som krävdes att arbeta med dem genom...

Välj alla som stämmer:

- ☐ **... universitetsutbildning?**
- ☐ **... praktisk erfarenhet?**
- ☐ **... företagsutbildning?**
- ☐ **... övrigt?**

25 Har det funnits tillfällen då du har... *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
... saknat tillräcklig kompetens inom hållbar utveckling?	○	○	○

26 Hur löste du problemet med avsaknaden av kompetens inom hållbar utveckling? *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Ja' på fråga '25 [A6]' (Har det funnits tillfällen då du har... (... saknat tillräcklig kompetens inom hållbar utveckling?))

Välj alla som stämmer:

- ☐ **Jag införskaffade mig den kompetens jag saknade.**
- ☐ **Jag fick hjälp av kollegor med högre kompetens inom hållbar utveckling.**
- ☐ **Jag lyckades inte lösa problemet på ett relevant sätt.**

Skicka in din enkät.
Tack för att du svarat på denna enkät.

Appendix I – Authors' student survey

Kort enkät om Chalmers utbildningar i hållbar utveckling

Det här är en kort enkät om Chalmers utbildningar i hållbar utveckling. Enkäten är en del av ett exjobb som genomförs på institutionen för energi och miljö. Målet med enkäten är att ta reda på vad Chalmers studenter tycker om de kurser som innehåller inslag av hållbar utveckling.

Enkäten innehåller max **10 frågor** och **tar inte mer än tre minuter** att svara på.
Välkommen att delta denna korta enkät om Chalmers utbildningar!

Uppdatering: Om du läser **Affärsutveckling och entreprenörskap inom byggteknik**, eller någon av **sjöfartsutbildningarna** kan du inte svara på enkäten. Skälet till att du ändå fått enkäten beror på att vi av misstag fick era mailadresser till utskicket.

Enkäten är en del av ett exjobb som genomförs på institutionen för energi och miljö. Målet med enkäten är att ta reda på vad Chalmers studenter tycker om de kurser som innehåller inslag av hållbar utveckling.

Enkäten innehåller max **10 frågor** och **tar inte mer än tre minuter** att svara på.

Tack för att du tar dig tid att svara på enkäten!

Den här enkäten innehåller 11 frågor

Chalmers utbildningar

1 Vilken typ av utbildning läser du? *

Välj **bara en** av följande:

- ◯ Civilingenjör eller arkitekt
- ◯ Högskoleingenjör

2 Vilket program läser du? *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Civilingenjör eller arkitekt' på fråga '1 [U1]' (Vilken typ av utbildning läser du?)

Välj **bara en** av följande:

- ◯ Arkitektur
- ◯ Arkitektur och teknik
- ◯ Automation och mekatronik
- ◯ Bioteknik
- ◯ Datateknik
- ◯ Elektroteknik
- ◯ Industriell ekonomi
- ◯ Informationsteknik
- ◯ Kemiteknik med fysik
- ◯ Kemiteknik
- ◯ Maskinteknik
- ◯ Teknisk design
- ◯ Teknisk fysik
- ◯ Teknisk matematik
- ◯ Väg- och vattenbyggnad

3 Vilket högskoleingenjörsprogram läser du? *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Högskoleingenjör' på fråga '1 [U1]' (Vilken typ av utbildning läser du?)

Välj **bara en** av följande:

- ◯ Byggingenjör
- ◯ Dataingenjör
- ◯ Designingenjör
- ◯ Ekonomi och produktionsteknik
- ◯ Elektroingenjör
- ◯ Kemiingenjör
- ◯ Maskiningenjör
- ◯ Mekatronikingenjör

4 Jag har... *

Välj **alla** som stämmer:

- [ ] ... läst en (eller flera) kurs(er) i miljö och hållbar utveckling
- [ ] ... läst en (eller flera) kurs(er) som har haft inslag av miljö och hållbar utveckling
- [ ] ... ***inte*** läst någon kurs i miljö och hållbar utveckling (och inte heller någon kurs med inslag av miljö och hållbar utveckling)

Dina åsikter

5 Vad finns det för bakomliggande drivkrafter som gör att företag idag arbetar med hållbar utveckling?

Välj **alla** som stämmer:

- [ ] Ekonomisk lönsamhet
- [ ] Vara en god samhällsmedborgare
- [ ] Värna om naturen
- [ ] Stärka företagets varumärke och goda rykte
- [ ] Jämställdhet mellan den rika och fattiga världen
- [ ] Eliminera företagets risker
- [ ] Skapa trygghet för framtida generationer
- [ ] Reducera företagets kostnader
- [ ] Möta kundernas efterfrågan
- [ ] Bidra till det lokala samhället

6 Vilka är de viktigaste bakomliggande drivkrafterna som gör att företag idag arbetar med hållbar utveckling?

Rangordna, genom att sätta ett nummer i varje ruta, från 1 till 10

- [ ] Ekonomisk lönsamhet
- [ ] Vara en god samhällsmedborgare
- [ ] Värna om naturen
- [ ] Stärka företagets varumärke och goda rykte
- [ ] Jämställdhet mellan den rika och fattiga världen
- [ ] Eliminera företagets risker
- [ ] Skapa trygghet för framtida generationer
- [ ] Reducera företagets kostnader
- [ ] Möta kundernas efterfrågan
- [ ] Bidra till det lokala samhället

7 Var har du bildat dig din uppfattning om vilka kunskaper som är viktiga för hållbar utveckling? *

Välj **alla** som stämmer:

- ☐ Genom de kurser jag läst på Chalmers
- ☐ Genom övriga informationskanaler (media, bloggar, tidningar, tv, kompisar m.m.)

8 Vilken har varit den viktigaste påverkan för att bilda den uppfattning du har om hållbar utveckling? *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var på fråga '7 [D1]' (Var har du bildat dig din uppfattning om vilka kunskaper som är viktiga för hållbar utveckling?)

Rangordna, genom att sätta ett nummer i varje ruta, från 1 till 2

- ☐ De kurser jag läst på Chalmers
- ☐ Övriga informationskanaler (media, bloggar, tidningar, tv, kompisar m.m.)

9 Jag upplever att utbildningen på Chalmers har utrustat mig med kunskaper och färdigheter så att... *

Välj det korrekta svaret för varje punkt:

	1 = Stämmer *inte alls*	2	3	4	5	6	7	8	9	10 = Stämmer *mycket väl*	Vet ej/ej applicerbart
... jag har god insikt i vad begreppet "hållbar utveckling" innebär.	○	○	○	○	○	○	○	○	○	○	○

10 Anser du att... *

Välj det korrekta svaret för varje punkt:

	Ja	Vet ej	Nej
... kunskap inom hållbar utveckling är relevant för din utbildning?	○	○	○

11 Hur mycket hållbar utveckling borde ingå i utbildningen på Chalmers? *

Svara bara på denna fråga om följande villkor är uppfyllda:
° Svaret var 'Ja' på fråga '10 [D3]' (Anser du att... (... kunskap inom hållbar utveckling är relevant för din utbildning?))

Välj **bara en** av följande:

- ○ *Alla* kurser borde innehålla inslag av hållbar utveckling
- ○ *Nästan alla* kurser borde innehålla inslag av hållbar utveckling
- ○ *några* kurser borde innehålla inslag av hållbar utveckling
- ○ *en* kurs borde innehålla inslag av hållbar utveckling
- ○ *Inga* kurser ska innehålla inslag av hållbar utveckling
- ○ Vet ej