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Safety management module to create social sustainability skills

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Abstract

Purpose - This study has a scope limited to a specific course and changes integrated to the core of KTH Naval Architecture Master Program. The students in the program have earlier experience from engineering applications in a general sustainability perspective and understand the basic concepts within sustainability. Therefore, in order to introduce further steps a new course module was introduced in 2018 focusing on safety management and the social sustainability. The purpose of this study is to identify and document the pedagogic lessons for a course module where sustainable development is discipline specific.

Design/methodology/approach - This study is a case study that qualitatively investigates the stainability effects of the implementation of the new course module. The course and program activities are compared to the results of a previous study in 2017 on the sustainable development learning elements in the program and discussed in relation to more general sustainable development initiatives.

Findings - From the analysis it is identified that the perspectives presented was new to a substantial part of the students. This study also shows that the effects of the specific module here studied, with focus on skill of maritime social sustainability development, differ from more general sustainability literacy. The new perspective affected the thinking about the core of the students' studies, ship design, in a way that general knowledge on sustainability has not. This was achieved with a combination of suitable tools and perspectives in in combination with a contextual knowledge and a frame of reference. The contextual knowledge and a frame of reference is here present in the education as a result of relating the sustainability case to the core of the program.

Originality/value - The result relates the pedagogical change described to sustainable development learning elements and to the ambition of the Conceive, Design, Implement, Operate (CDIO) approach. This paper contributes to the literature by providing a discussion on how social sustainability can be implemented in engineering education and the role of integrated discipline specific sustainability modules.

Key words: Engineering education, Social sustainability, Safety, Discipline specific engineering skills

Paper type: Case study

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1. Introduction

Naval Architecture is a mechanical engineering discipline that considers (technical) systems for maritime use; such systems include boats, ships, offshore platforms and underwater systems. The use of these systems, for example in transport, in shipping and in the oil industry, largely shape the conditions for today's societies. Typically, today's engineering education at KTH generally and in the KTH Naval Architecture Master Program considers sustainable development. However, mostly limited to areas such as energy efficiency and CO_2 emission. Also, ship safety and economic aspects are discussed (Rosén, 2017). Does this approach really address the interaction between societal changes and engineering that is needed from the engineers of the future?

"Engineering education professionals tread on unfamiliar ground when entering transdisciplinarity approach, as it includes social sciences and humanities perspectives" (Tejedor et al., 2018) and studies show that social sustainability so far only have attracted limited attention in engineering education and is considered challenging as a result of their value laden nature (Edvardsson Björnberg et al., 2015, Tejedor et al., 2018). Therefore, it is here assumed that the efforts in relation to sustainability at KTH so far is only one step on the way to produce effective engineering skills that contribute to a sustainable future.

With the aim to identify successful aspects of how to implement social sustainability into engineering education this study qualitatively investigates the results of the implementation of a new course module. The study is based on analyzing the sustainability development learning elements (Rosén, 2017) in the program before and after the new course module. The text is intended for faculty, specifically engineering faculty, working with pedagogic and course development with the intent to support further development of pedagogic approaches for sustainability development and the social aspects involved.

Sustainable development in engineering education can and is discussed in general or as a topic of its own and with a focus on environmental, green or ecological. However, this study specifically analyzes the limited scope of *social* sustainability as an *integral part* of the core applied courses of the specific engineering discipline naval architecture, i.e., discipline specific sustainability knowledge. This analysis focus on the pedagogic difference between the more common general approach and the integrated approach here specially studied.

In Section 2 Approach and methodology, the program context, the pedagogic perspective and the social sustainability perspective used in this study are stated. Section 2 also describes the sustainable development learning elements approach developed by Rosén (2017). In Section 3 Data the program is described in a sustainable development perspective before and after implemented changes. In Section 4 Analysis, the effects of the changes are quantitatively analyzed and then discussed in Section 5 Discussion.

2. Approach and methodology

2.1 Program context and previous studies

The Naval Architecture Master Program was formally established at KTH in its current form as an international master program in 2010. However, the master program is based on more than 100 years of naval architecture education at KTH with a pedagogic tradition developed during the period 2001 to 2010 for the courses given to students at the national five-year Master of Science program in vehicle engineering majoring in naval architecture. The pedagogic approach is based on the Conceive, Design, Implement, Operate (CDIO) approach founded in 2000 by Massachusetts Institute of Technology, Chalmers Institute of Technology, KTH Royal Institute of Technology and Linköping University (Crawley et al., 2014). The rationality behind this approach in relation to the program is to create an integrated curriculum where discipline-led and problem/project-led learning are combined to create engineering skills. The pedagogic development of the naval architecture courses are described in several case studies (Edström et al., 2005, Edström et al., 2011, Edström and Kolmos, 2014, Malmqvist et al., 2004, Young et al., 2005). Parallel to the program and course development also the teachers involved in the program were involved in a CDIO-based faculty development initiative at KTH (Edström, 2017). Therefore, the pedagogic perspective of this study is based on the CDIO-approach as described in Section 2.2.

After establishment of the program in 2010 the development has focused on internal development of the courses and pedagogic approach to make sure that the program continues to meet the goals of the Swedish Higher Education Ordinance (Sweden, 2016). Of extra importance to this study is the development in relation to sustainable development and the exchange of pedagogic experience in relation to the sociotechnical perspective with the Swedish Defence University.

There were integrated sustainable development degree requirements for the program from the establishment in 2010. However, the meaning and understanding of these goals has been sharpened over the years. Therefore, Rosén (2017) performed an analysis of the integration of sustainable development into the program in 2017. The approach used in that study, analyzing the sustainable development learning elements, has also later been used to analyze the integration of sustainable development in several other educational programs at KTH and other Swedish universities. The integration of sustainable development into this program has therefore drawn from several different works, including further development of the CDIO approach and its relation to sustainability (Malmqvist et al., 2019). The social sustainability perspective applied in this study is presented in Section 2.3 and the analysis approach based on the study performed in 2017 is presented in Section 2.4.

Since 2015, there have been an informal exchange of pedagogic experience between KTH Centre for Naval Architecture and faculty at the Swedish Defence University involved in the master level Advanced Command Program with focus on military technology for Swedish military officers. The program is a part of the step from the rank major to lieutenant colonel. The experience from the military education in relation to the sociotechnical perspective has been used to formulate approaches for education related to social sustainability for engineers. The experience is based on education related decision-making in the development and implementation of technical systems into military organizations, for example military utility of technical systems (Andersson et al., 2015), pedagogic approaches for military risk management (Liwång, 2017). The experience from the Swedish Defence University has been important in the development of the pedagogic approach here studied. The similarities and differences to the experience from the Swedish Defence University are discussed in the results.

2.2. Pedagogic perspective

This study as well as the course and program changes discussed are based on the CDIO approach. Here the CDIO approach is understood as a discipline-led approach that educate for a professional practice that provide conceptual understanding and deep learning of systematically organized knowledge where disciplinary fundamentals are a core building block. This is done with an integrated curriculum where discipline-led and problem/project-led learning are combined to create engineering skills. The synergy between the learning approaches comes from the fact that students simultaneously work with disciplinary knowledge and professional skills (Edström and Kolmos, 2014).

In the CDIO approach, project-based learning activities are designed to reinforce the students' disciplinary understanding by applying the knowledge. Therefore, the practical activities are intended to increase motivation for understanding theory, but are not intended to replace discipline-led activities as the primary source for systematic disciplinary knowledge (Edström and Kolmos, 2014). As a result of the CDIO approach the description of the introduced changes is in this study divided into the sub-areas introduced discipline focused activities, introduced problem/project focused activities, and connections to existing activities in the course.

2.3. Social sustainability perspective

Shipping has, thanks to the relatively high transport efficiency, a large and important role in how recourses and goods reach different societies. However, in relation to social sustainability the maritime industry, despite considerable improvements, suffers from high levels of occupational morbidity and mortality compared to similar shore-based occupations (Ellis et al., 2011, Oldenburg et al., 2010, Roberts and Marlow, 2005). On board ships there are psychological stressors that effect health, well-being and performance (Österman, 2012, Comperatore et al., 2005). Working conditions at sea are characterized by long working hours, shift work, high demand and low control, conditions that cause occupational stress and ill-health (Karasek and Theorell, 1990). Seafarers are also the most isolated demographic group in the world, both in terms of social isolation from family and home, as well as isolation from emergency medical and primal health care (Liwång et al., 2015).

Maritime work represents special risks to life and health because of the working conditions on board. Therefore, better working conditions are important. This means the personnel should be entitled to for example good living conditions, regular communications with home, ensuring regular payments, proper medical care and well-being independent of nationality, flag state of the ship etc. (Moreira, 2014).

Therefore, the understanding in this study is that sustainability in shipping and at sea cannot be reached without the development taking social considerations and that there are important discipline specific sustainability aspects related to naval architecture. The focus in engineering is thus how the design of the vessel interacts with the system characteristics of the socio-technical systems that the vessel is a part of during life cycle phases such as design, construction, operation and disposal and recycling. Throughout these phases, emergent system properties of the socio-technical systems are a result of, at least to part, the design choices made by the engineer. Reducing negative societal consequences during these phases are important.

2.4. Analysis approach

This study qualitatively investigates the results of the implementation of a new course module on safety management. The investigation is based on course data, student reflections and course evaluations. The results are structured with the CDIO approach and compared to the results identified in 2017 when the sustainable development learning elements in the courses in the KTH Naval Architecture Program were analyzed and described by Rosén (2017).

With the aim to further improve the conditions for students in the KTH Naval Architecture Program to increase their knowledge and skills in relation to the sustainable development Rosén (2017) developed an analysis scheme based on the Swedish degree requirements related to sustainable development for the degree Master of Science in the Swedish Higher Education Ordinance (Swedish Council for Higher Education, 2019). Such degree requirements include that a student shall be able to, *directly* related to sustainable development, "demonstrate the ability to develop and design products, processes and systems while taking into account the circumstances and needs of individuals and the targets for economically, socially and ecologically sustainable development". Also, a student shall also be able to, *indirectly* related to sustainable development meet goals such as be able to "demonstrate the ability to identify, formulate and deal with complex issues autonomously and critically and with a holistic approach" (Swedish Council for Higher Education, 2019). Based on the degree requirements Rosén (2017) identified and defined the following four levels of integration of sustainable development, Sustainable Development Learning Elements (SDLE:s):

Level 1 "Engineering applications" is only indirectly related to sustainable development, and considers development of students' generic engineering abilities according the learning objectives indirectly related to sustainable development. However, these abilities are an important stepping-stone on the road to sustainable engineering practice.

Level 2 "Exposure to Sustainable Development" is about exposing students to problems related to sustainable development in areas such as energy and resource efficiency, human factors, and economical aspects. At this level the main aim is to develop awareness.

Level 3 "Literacy for Sustainable Development" considers development of students' sustainable development knowledge such as terminology and knowledge about societal policies.

Level 4 "Expertise in Sustainable Development" considers development of engineering skills and abilities directly related to sustainable development including system analysis methods and life cycle analysis approaches.

The Sustainable Development Learning Elements together are used in Section 4 as evaluation criteria to analyze the new course module.

3. Data

3.1. Education structure and courses

The Naval architect program is a two-year Masterprogram that both serves as the two last years of the five-year education for KTH Master of Science students as well as a standalone master program for students from other universities worldwide with a suitable bachelor degree. The program consists of mandatory core courses, mandatory track courses in three different study tracks, and elective courses.

The three mandatory naval architecture courses are performed during the first two semesters, the courses Ship design (9ECTS) and Marine structures (7.5ECTS) during the first semester and Marine hydromechanics (7.5ECTS) during the second. Therefore, the course Ship design introduces central naval architect topics such as ship stability and resistance; introduces naval architect engineering methods such as systems engineering; and largely defines and frames the understanding of naval architecture as an engineering discipline for the students.

3.2. Identified sustainable development learning elements in 2017

When analyzing the program in 2017 Rosén (2017) identified that the courses in the program addresses sustainability aspects. Sustainable development learning elements at Level 1 through 3 are implemented in a balanced way in most of the courses. However, only the study track Management includes Level 4 Sustainable development learning elements and therefore is the only track that includes development of engineering skills and abilities directly related to sustainable development. Based on the identified sustainable development level of the courses, the study tracks and the program Rosén (2017) proposes that the course Ship design (9ECTS) could have a key role introducing and establishing a baseline for sustainable development which could be used as a basis for the following courses.

However, analyzing the result by Rosén (2017) with a social sustainability perspective also show that the focus in the education is on ecological sustainability and only to a limited extent on how the systems under design interact with our societies which at least indirectly will affect all aspects of sustainability.

3.3. Introduced changes in 2018

Within the KTH bachelor education, the students are introduced to basic concepts of gender equality issues and sustainable development.

With the aim to reach further than sustainability literacy and ecological sustainability a new course module focusing on safety management was introduced during 2018 in one of the courses in the KTH Naval Architecture Master Program. Safety management is a topic important for the development of maritime systems (manned and unmanned). It is also a topic that can question the order of today's maritime engineering and management and a topic that introduces new perspectives and skills into the engineering field. With the new module's focus is put on skills for increasing the social sustainability of the life cycle of the ship including design, construction, operation, disposal and recycling. The objective is to introduce tools for analyzing the operational aspects of shipping and how the social conditions for maritime activity is affected by design. The ambition is to introduce and define safety management, and the social sustainability aspects that are included, as a natural and integral part of naval architecture. This with the aim to affect all courses within naval architecture and to affect the future faculty development.

More specifically the changes mean that in the course Ship Design (9ECTS) a general ship design group-project in the end of the course was, in 2018, replaced with a more specific safety management group ship design project module. This allowed for also including new discipline related lectures. The new module is intended to complement existing knowledge perspectives with a perspective that is inter-disciplinary and captures social as well as technical aspects of design, i.e. an injection of a contrasting perspective on design and engineering. This fits with existing intended course and program learning outcomes and goals. However, it also introduces a new level of ambition in relation to social change. The ambition with the module is to introduce and define safety management, and the social sustainability aspects that are included, as a natural and integral part of naval architecture. This with the aim to indirectly change the learning that is taking place throughout the program and to affect the future faculty development.

3.3.1. Introduced discipline focused activities

Before the module the students' sustainable development knowledge such as terminology and knowledge about societal policies in relation to ship design is examined

In four two-hour lectures, new discipline knowledge is introduced in the course. This new discipline knowledge is both described in the lectures and in the course literature. The knowledge and perspectives presented therefore have a clear link to ongoing research and knowledge development. The themes and literature for the lectures are:

- Contextual knowledge: The principles for modern maritime safety. Highlights the social aspects of the formulation and development of safety principles (Kuo, 2007, Vassalos, 2009).
- Methodologic approaches for future safety management regimes here conceptualized by maritime risk based ship design (Vassalos, 2009).
- Tools for future safety management regimes here conceptualized by the Formal Safety Assessment framework (IMO, 2013).
- Maritime human factors and participatory design (Oltedal and Lützhöft, 2018).

The chosen literature also covers a relevant and complementary set of maritime safety management cases.

3.3.2. Introduced problem/project focused activities

The main learning activity in the new module is the maritime safety management project-assignment. In the assignment, the students work in groups of four with one conceptual design for a Roll on Roll off (RoRo) ship. The course director assigned the group participants and the design to work with.

In the project, the focus is on "the system's (ship/ships, ports and crews) ability for achieving high safety (here interpreted as an operation that has a low probability of incidents that can lead unwanted effects on the crew). The ship operator has identified that extra care of personnel will both be a method for creating a sustainable operation and an important commercial strategy" (from Project task description, KTH 2018). The students therefore are tasked with redesigning the ship to reduce the negative social impact of the operation. Each group should also comment on the effects that the proposed changes have on sustainability in general. Therefore, the task also included decision making and risk communication which is shown to be important to reach risk management skills in a setting where there are few/no objective risks (Liwång, 2017).

The purpose is to give the students "opportunities to develop … knowledge and understanding of the scientific basis and proven experience of ship design and applying the theory and methods … in a realistic context" (from Project task description, KTH 2018).

The groups are expected to present the work in a final report, an oral presentation and each student is expected to present a one-page personal reflection on the work.

3.3.3. Connections to existing activities in the course

The new safety management module is the last module of the course Ship design (9ECTS). There are several activities performed in the other modules of the course that connects with activities within the safety management module. Particularly the following three activities have an important role in giving the students the conditions for taking on the module:

- A personal traditional ship design project where the students design a ship for a specific transport scenario where safety is treated as a constraint.
- A study tour on a RoRo-ship, which highlights how the work on board (navigation, cargo handling, maintenance etc.) is affected by design.
- A sustainability workshop where the United Nations sustainable development goals are discussed and analyzed in relation to ship design, shipping and maritime systems.

These three activities are important in creating a frame of reference for naval architecture in relation to systems engineering approaches, maritime operations and sustainable development.

4. Analysis

This analysis is based on the framework presented in Section 2 and analyzes lessons learned in two performed course offerings, one 2018 and one 2019.

4.1. Analysis in relation to sustainability development learning elements

In the course, before the new module, the students have taken part in a written exam that for 2018 and 2019 included one part about sustainability in relation to naval architecture. In the answer to that part, the students were able to use basic sustainability terminology and relate ship design to major sustainability challenges. Therefore, before the module starts the students has shown that they in relation to the scope of this course meet the requirements of Sustainable Development

Learning Elements level 3 “Literacy for Sustainable Development”. This supports the findings of the analysis of the program performed in 2017 (Rosén, 2017).

The ambition of the changes implemented is to reach to Level 4 Expertise in Sustainable Development. This is achieved if the education develop engineering skills and abilities directly related to sustainable development including system analysis methods and life cycle analysis approaches. This means being able to apply methods and tools including “taking into account people’s situations and needs and the society’s objectives for … socially … sustainable development”; “an ability to make assessments in their main field of study, taking into account relevant scientific, social and ethical aspects”; and “insight into the potential and limitations of technology and science, its role in society and people’s responsibility for how it is used, including social and economic aspects, as well as environmental and work environment aspects” (Swedish Council for Higher Education, 2019).

By examining the personal reflections, it can be seen that all students were able to apply the new discipline knowledge and tools in the project work and a majority of the students explicitly identified and articulated the change in system perspective compared to the traditional engineering and ship design task performed earlier in the course. The result of textual analysis of the personal reflections is presented in Table 1.

Table 1. Analysis of personal reflections in relation to ability to make assessments informed by relevant social and ethical aspects.

Analysis area	**Present in the reflections***
Demonstrate ability to make assessments informed by relevant social and ethical aspects	76 percent

** Note that this aspect was not required or measured in the course, i.e., the measure does not reflect the quality of the students’ reflections.*

The main tool introduced and used throughout the safety management module is risk management and it is complemented with a socio-technical lifecycle perspective. The students have shown that they can identify conflicting social interests for different stages of the lifecycle and provide sound recommendations on possible decision-making considering social values. To achieve this the project task should be complex enough to create the need for compromises between different solutions and value. However, the task should not be so complex that the students are not able to relate to the task and the design they are working with. Therefore, the performed traditional ship design project and study tour on a RoRo-ship are important frames of reference throughout the maritime safety management task. It is also identified that knowledge and ability in relation to risk management in general is not enough to create social sustainability skills.

The module created system focus-shift from the physical ship to the socio-technical system of which the ship is an important part and contextual knowledge was key in order to connect general tools to skills. However, the collective, and different perspectives represented by different students, was needed to create a complete enough life cycle understanding to avoid sub-optimization of specific life cycle phases.

In addition, the joint faculty and student program evaluations, a part of the university’s education quality assurance process, has been used to understand the change achieved. Based on that analysis it has been identified that in later courses students that has participated in this new module asks for information about societal interconnections for the areas discussed, this has not been identified before. This is by the faculty understood as an attempt to put acquired sustainability development literacy and skills to work also in other courses.

The identified changes of the new module are summarized in Table 2 in relation to the Sustainable Development Learning Elements.

Table 2. Included Sustainable Development (SD) Learning Elements before and after the change.

Analysis area	**In 2017**	**After implementation of new module**
Level 1, Engineering applications	Yes, main focus of course.	Yes, main focus of course.
Level 2, Exposure to SD	Yes, workshop and individually examined.	Yes, workshop and individually examined.
Level 3, Literacy for SD	Yes, workshop and individually examined, focus on ecological SD.	Yes, workshop and individually examined, broaden to also include social and economic SD.
Level 4, Expertise in SD	No.	Yes, discipline specific group report, oral presentation and reflection.

4.2. Analysis in relation to the CDIO approach

The aim is to create an integrated learning activity where discipline-led and problem/project-led learning are combined to create engineering skills. Therefore, three different types of learning activities were introduced:

Step 1: Introducing new perspectives, new discipline knowledge and tools, in the ship design process formally changing the system focus. (Potentially changing how the system is conceived and designed)

Step 2: Open-ended task in a relevant context in with conflicting social values forced the students to face the effects of the different social norms at play. Including full class seminars when the different groups approaches are discussed allowing for highlighting the relation between the work done and the new discipline knowledge, i.e., actually change how the system is conceived and designed and experience how the tools can be implemented.

Step 3: Allowing and facilitating the students to reflect on the change achieved in a separate and personal reflection on the work performed in the module.

The students are able to move between these activities and apply tools and reflections from one in another. Forcing the students to apply the new discipline knowledge and tools in an open ended task accentuates the need for mastering the challenges identified. The open ended task lead to that the respective groups owned the problems they encountered. They identified the lack of facts and the challenge in comparing the severity or urgency of different types of consequences and risks. For example, there were conflicting risk reduction needs dependent on the risk perspective used (life risk, local environmental risk, and global environmental risk). Also, different life cycle phases had conflicting needs.

4.3. Actual change achieved

From the joint faculty and student program evaluations it is identified that in order to create the effects described in Section 4.1 and 4.2, the contextual knowledge as well as having an understanding of the traditional/norm of design in the field is important. From the analysis it is also identified that the perspectives presented was new to a substantial part of the students. The students also identified the changes that the perspectives implied on the systems engineering process and how social sustainability aspects such as industry tradition, international safety regulations and life-cycle rationality can be affected by engineering approaches and actions. The findings are summarized in Figure 1.

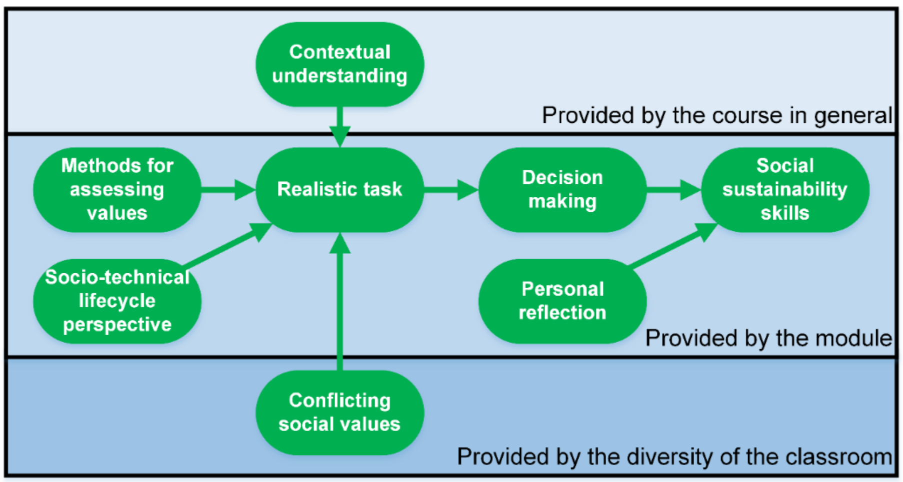

Figure 1. The elements at work to create social sustainability skills.

It is the risk management ability *in combination with* the understanding of the relevant sustainability challenges and a more holistic or socio-technical system perspective that is needed. If the challenges are not understood or correctly framed the engineering solutions produced do not create or increase social sustainability. This is here created because of the module being included in the student's main field study (naval architecture). This means that stand alone, or general, sustainability development modules could have a limited effect if not combined with suitable contextual knowledge. During the course, in the presentations, in the personal reflections and during the evaluation of the course the students stress the importance of the strong link between contextual understanding, realistic task and the social values at play. The relationship between these three areas is paramount to the result achieved with the module and the students identify that their general knowledge in relation to the context of the module is weak. The course builds on a situation where the students share an interest in the maritime industry, where many has years of experience from the field or industry, where the participants have spent weeks together on the concept of ship design, and yet this is barely enough to be able to create a realistic setting where they can practice social sustainability skills.

Will these learning outcomes actually change the students' future social sustainability engineering skills? As shown in Table 3 the analysis also shows that these engineering students are accustomed to text book tasks with identifiable and objective input and answers that are either right or wrong.

However, in order to achieve social sustainability engineering skills the students must understand that importance or severity of different types of risks cannot be assessed objectively, it must always be assessed contextually and will be dependent on the social norms applied (Aven and Krohn, 2014, Kenter et al., 2019). This challenge can be presented at a lecture, but the experience from this course is that the discussions in the multinational groups are needed in order to achieve an understanding. However, the understanding requires that the student acknowledge the legitimacy of different and varying cultural and social values. Therefore, it is not guaranteed that the activities performed in the case here presented are enough to create the same level of understanding for all students. Therefore, this value laden aspect of social sustainability is something that teachers in engineering education finds challenging (Edvardsson Björnberg et al., 2015) is here shown to be crucial to capture realistically in order to reach change.

Table 3. Analysis of personal reflections in relation to open-ended tasks and value-related decision-making.

Analysis area	**Present in the reflections***
Not used to open-ended tasks with a high degree of value-related decision-making	72 percent

** Note that this aspect was not required or measured in the course, i.e., the measure does not reflect the quality of the students' reflections.*

The task in the course highlights the difference between being able to perform the steps of a risk analysis and being able to apply a risk management approach with the aim to take effective design decisions that affect social aspects of the system throughout the system's life cycle. Most probable more perspectives on both technical and social aspects of the systems life cycle are needed to create an understanding on how the system (the ship) interacts with its environment, social structures and societies throughout the design, construction, use and recycle and disposure. Therefore, it is identified that implementing the correct learning elements is not enough in order to create the highest level of social sustainability understanding. For the students that showed evidence of an effective focus shift taking part in the learning activities was not enough, they do also perform a personal reflection on the social values involved. A reflection often catalyzed by the social and cultural diversity of the classroom. This is a result a teacher can hope for, but it is a challenge to make sure that all students will reach such results. By comparing the two different course offerings, it is also evident that the effect of social and cultural diversity is not constant.

Ecological sustainability can be, or is in a controlled setting often assumed to be, assessed with objective natural sciences measures (the solution with the lowest CO_2 emissions is "the best"). Social and economic effects are not objective; they are subjective or dependent on social norms, context, conventions and assumptions. The value of a consequence and system output is not constant; it is a function of the norms and values of our society. There is a large interaction between sustainability and values (Kenter et al., 2019). Examples of this surface during the course. However, the theory of social values for sustainability (Kenter et al., 2019) were not explicitly discussed in the course module studied here. Therefore, in this course change was implicitly introduced. To reach further, to create articulated social sustainability skills and explicit change, more time, theory and activities are needed on the change itself. The course then needs to discuss what change is and how it comes about. This includes socio-technical theory in relation to shipping and ship design (Schröder-Hinrichs et al., 2012), in relation to how to analyze and structure interactions between social and technical system components in general (Ingelstam, 2012), in relation to sustainability (Savaget et al., 2019), as well as knowledge on technological transition and its social functions (Geels, 2002). The general structure of the elements at work (from Figure 1) in relation reaching even further and creating aware ambassadors of the future of engineering is presented in Figure 2.

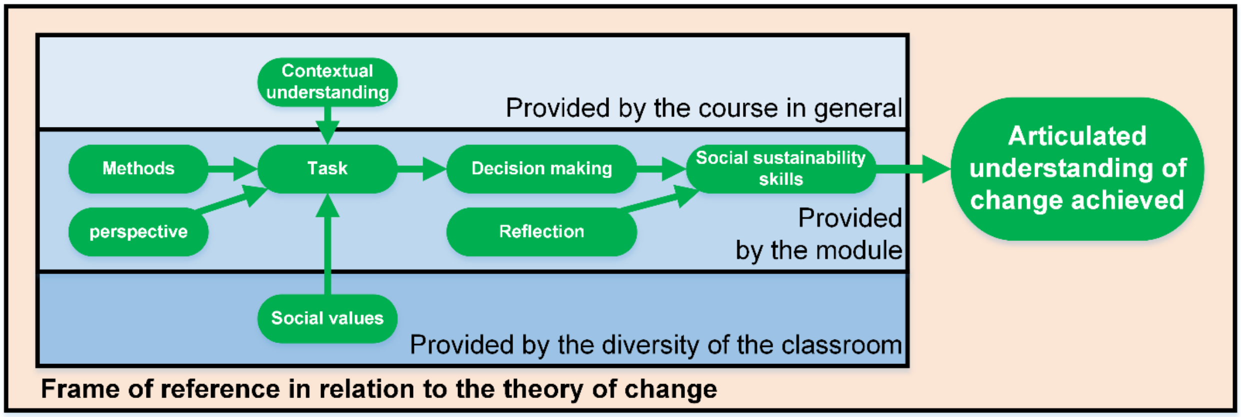

Figure 2. A possible way to create ambassadors for change.

The new module has the power to change the students' activities in other courses such as project courses, thesis work and gives the students discipline specific skills and knowledge that can be used in management courses that deepens the view on sustainability. However, it is only a starting point for further program development and it is important to evaluate the effects of education in relation social sustainability on the decisions of the students after they enter their professional careers.

4.4 Generalizability of the results

This study is based on a single case study and its findings are therefore to be seen as an example of the possibilities with social sustainability perspectives in engineering education. The results have also been compared to the experience from the Swedish Defence University in relation to analysis of technology use as described in Section 2.1. The students at the Swedish Defence University generally also comment on the same frustration about the substantial difference between the objective and quantitative characteristics of technical systems on one hand and the subjective and value laden effects achieved when the technical system is put into an organization. However, the relatively more homogenous student group (in terms of nationality, age, and work experience) at the Swedish Defence University does not force the students to identify and acknowledge that there are alternative value lenses and perspectives. The relatively larger contextual understanding of the military officers does not compensate for the only limited conflicting values in the class room. Therefore, the comparison of the results found in this study to the experience from the Swedish Defence University supports the general findings related to elements at work summarized in Figure 1.

4.5. Summary of the results

This study shows that the specific module here studied, with focus on discipline specific skill of maritime social sustainability development, differ from more general sustainability literacy. The new module showed the students that safety is not a constraint, it is a design parameter that effects several value creating social aspects of the ship's life cycle. The course module also introduced the socio-technology system perspective into the program. Therefore, the new perspective affected the thinking about the core of the students' studies, ship design, in a way general knowledge on sustainability has not. This was achieved with a combination of suitable tools and perspectives in relation to contextual knowledge and a discipline specific frame of reference.

The central contextual knowledge and a known frame of reference is here present in the education as a result of relating the sustainability case to the core of the program. This allowed for a suitable combination of theory and practice that the students were forced to reflect upon. This meets the ambitions of the CDIO approach to create a discipline-led approach that educate for a professional practice.

However, to reach all the way to an engineer that always/automatically will strive for change more time need to be spent on change itself and the interactions between social and technical system components. In the module here studied such aspects were only implicitly discussed. Further development is needed.

5. Discussion

This study has a scope limited to a specific course and changes. There is a need for more studies on the specific interaction between different disciplines their tools and sustainability. It is also suitable to further investigate the real-world impact of this type of changes of the curriculum.

Changing how (ship) design is perceived in this course have the power to change the understanding of the other courses within the program. The new topic, maritime safety management, highlight areas such as maritime social sustainability, gender, the human element, maritime management, autonomy and ethics. The topic also introduces guest lecturers from outside the typical engineering and naval architect norm.

The new course module was designed to achieve change within the program and have here primarily been discussed in relation to changes in the education and the students. According to Högfeldt et al. (2018) in order to create actual change also teachers and personnel, organization and external cooperation need to be considered. Therefore, these aspects are discussed briefly below.

Actions for teachers and personnel. The topics maritime safety management and social sustainability are also partly new for teachers within other core courses and is generally considered to be a challenge by teachers in engineering education (Edvardsson Björnberg et al., 2015). Therefore, an important subsequent action is to develop a common understanding of how social sustainability and safety management could be a part of other courses. For example, could a more philosophical perspective on sustainability be achieved if the perspectives are applied on maritime autonomy and unmanned underwater systems. Future possibilities also includes to further strengthening the link between the ship as workplace in relation to ship dynamics within the course Marine Hydromechanics. This link is also an area of ongoing research efforts.

Actions in regards to organization and external cooperation. Judging from research projects at KTH Centre for Naval Architecture external parties acknowledge the importance of the fields safety and sustainability and that approaches for dealing with the related design challenges are important for successful engineering. However, at the same time, the incentives at KTH for introducing skills related to value and social norms such as maritime safety and sustainability development into a course is low. Therefore, there is no substantial resistance for integrating social sustainability and especially safety into the education, but it requires internal initiatives. The introduced perspectives also affect how research, as well as industry representation, are and can be involved in the courses and program and introduces new possibilities for the future.

In sum, this was a good step, but only one of several needed, on the way to more social sustainability aware naval architects. Future development includes to further strengthening maritime safety management into all core courses.

6. Conclusions

This study has a scope limited to a specific course and changes. The students are during the program already exposed to sustainability aspects, have discussed engineering applications in a sustainability perspective and understand the basic concepts within sustainable development. This study shows that the specific module here studied, with focus on the discipline specific skill of maritime social sustainability development, differ from more general sustainability literacy. The new module showed the students that safety is not a constraint, it is a design parameter that effects several value creating social aspects of the ship's life cycle. The course module also introduced the socio-technology system perspective into the program. Therefore, the new perspective affected the thinking about the core of the students' studies, ship design, in a way general knowledge on sustainability has not. This was achieved with a combination of suitable tools and perspectives in relation to contextual knowledge and a frame of reference. The central contextual knowledge and a frame of reference is here present in the education as a result of relating the sustainability case to the core of the program. This allowed for a suitable combination of theory and practice that the students were forced to reflect upon that meet the ambitions of the CDIO approach to create a discipline-led approach that educate for a professional practice. However, to reach all the way to an engineer that always/automatically will strive for change more time need to be spent on change itself and the interactions between social and technical system components. In the module here studied such aspects were only implicitly discussed. Further development is needed.

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