A FRAMEWORK FOR A SUSTAINABILITY TRANSITION OF TWO ENGINEERING MASTER'S COURSES

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ABSTRACT

Sustainability, as a concept, is permeating most of today's human activities, including higher education. The increased importance put on sustainability depends largely on the increased awareness of the huge environmental, social, and economic challenges that humanity is currently facing. As is the case with most complex themes, the route towards the application of appropriate actions starts with enlightenment developed within education, where different engineering programs form important subareas. To address this, CDIO Syllabus 3.0 in general, but optional standard 1 in specific, does now to an even greater extent handle sustainability issues. This paper presents a framework that is built upon several key concepts that are strongly related to education for sustainable development (ESD) at the university level, such as key sustainability concepts (as defined by UNESCO), sustainability development goals (as defined by the United Nations) and constructive alignment (as defined by Biggs and Tang). The framework is applied to two engineering master's courses where sustainability concepts and development goals are integrated and constructively aligned in the learning outcomes, teaching and learning activities, and assessments. Through the analysis of the two courses concerning sustainability, the framework is shown to provide a means for the analysis of how sustainability is currently incorporated in a course, highlight what possible teaching/learning shortcomings exist, and help identify actions that can be taken to overcome these shortcomings. The objective of the framework is thus to support course managers in the development of appropriate actions related to sustainability.

KEYWORDS

Constructive alignment, Education for sustainable development, Sustainability competences, Sustainability transition, Standards: optional standard 1

INTRODUCTION

Sustainability is an increasingly important topic in today's world, and its impact on university teaching is becoming more and more evident. At university level, sustainability is being integrated into curricula across many different disciplines, including engineering. By teaching students about sustainability, universities are helping to equip the next generation of engineers with the skills and knowledge to create sustainable solutions for the future. Through a combination of hands-on projects, lectures, case studies, and internships, engineering students are being exposed to the principles of sustainability and learning how to design and

build solutions with a long-term, sustainable perspective. By learning about sustainability, engineering students are better prepared to help create a more sustainable world.

To analyze the curricula of an engineering course with respect to its handling of sustainability issues, a framework has been conceived. It is built upon four pillar stones, namely *sustainability transition* (Sterling and Thomas, 2006), *competences in sustainability* (Rieckmann, 2017), *sustainable development goals* (UN, 2015), and *constructive alignment* (Biggs and Tang, 2011).

As a basis for the analysis of the framework and its applicability to the incorporation of sustainability in engineering programs, two courses taught at master's level at the school of engineering at Jönköping University have been chosen. The first course is *Industrial Placement Course* (IPC), which is a 9 credits course that runs in the third semester of the two-year master's program Software Product Engineering, SPE. The second course is *Industrial Product Realization in Collaboration* (IPRIC), which is a 6 credits course that runs the first semester in all of the six master programs at the school of engineering (i.e., Industrial Design, Product Development and Materials Engineering, Production Development and Management, Software Product Engineering, Sustainable Building Information Management, and User Experience Design and IT Architecture). Both courses have pros and cons when it comes to incorporating sustainability as will be demonstrated further on.

The rest of this paper is divided in four sections. First, the theoretical background of the four pillar stones of the framework is presented. Next comes a section on the analysis of the two courses applying the framework followed by a section on how to increase the sustainability content in the two courses making use of the previous analysis. Finally, a discussion section ends the paper.

THEORETICAL BACKGROUND

In continuation are presented the four pillar stones that the developed framework in this paper is based upon.

Sustainability transition

Sterling and Thomas (2006) identified four stages in the transition towards sustainable education in universities (table 1).

Table 1. Stages for the development of sustainable education in universities (Sterling & Thomas, 2006)

Sustainability transition	**Response**	**State of sustainability (societal change)**	**State of education (educational change)**
Very weak	Denial, rejection, or minimum change	No change	No change
Weak	'Bolt-on'	Cosmetic reform	Education *about* sustainability
Strong	'Build-in'	Serious greening	Education *for* sustainability
Very strong	Rebuild or redesign	Wholly integrative	Sustainable education

The strive should be to reach the higher stages in the transition, something that is further elaborated on in relation to the master's courses further on.

According to DuPuis and Ball (2013, page 65), it is essential to move from a simple *know what* to a more complex *know how* to increase the sustainability awareness among students. *Know what* implies 'a focus on sustainable knowledge and practice as simply gathering and imparting to students the right codified information [that] has led to confusion in the classroom'. This is sometimes known as a summative approach. *Know how* implies a move towards interactive and collaborative platforms that promote five key competences (Wiek et al., 2011), which are further described in the next section. Thomas (2009) recommends problem-based learning as a vehicle towards a deeper understanding of different topics in education in general and sustainable education in specific. This is sometimes known as a formative approach. In the case of the IPC, problem-based learning comes naturally as students realize work in a real work environment during a 5–10-week period. The same goes for the IPRIC course where problem-based learning also plays a key role in the development of a project in a multi-cultural, multi-discipline and holistic setting. More about this later.

Barth et al. (2007) describe that key competences, like the ones presented further on, are required for forward-looking and autonomous participation in shaping sustainable development. A possible problem is that some experts state that competences are learnable but not teachable. If this is the case, how can the acquisition of such competences be observed and assessed? Barth et al. (2007) describe key competences as the interplay of cognitive and non-cognitive components. The authors argue that the acquisition of cognitive components is traceable when constructing *mental models*. A challenge is to choose the most adequate model as there literarily exist hundreds of them. Likewise, the acquisition of non-cognitive components (which is an interiorization process) are traceable through *production/reproduction* and *reception/communication*. Hence, the students must be enabled to discover and analyze their own value system, and to revise it with respect to its adequacy to reality. Consequently, the implementation of suitable teaching/learning activities and assessment tasks would be a way of reaching stage 3 (strong) on the sustainability transition ladder (table 1).

Stough et al. (2018) present a number of pedagogical sustainability assessment approaches applied in a one-year master program that prepares students for a career in the international business world by developing students' (business) economic acumen, knowledge, and management skills (table 3). Some of these approaches are used, and others could be used, in both the IPC and the IPRIC courses.

Sustainability competences

In 2017, the United Nations Educational, Scientific and Cultural Organization (UNESCO) presented a publication on education for sustainable development, ESD (UNESCO, 2017). The publication outlines eight key sustainability competences (KSC) required to advance ESD (table 2).

Table 2. Key sustainability competences (UNESCO, 2017)

1	**Systems thinking competence**: the ability to recognize and understand relationships; to analyze complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty.
2	**Anticipatory competence**: the ability to understand and evaluate multiple futures – possible, probable, and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
3	**Normative competence**: the ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.
4	**Strategic competence**: the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
5	**Collaboration competence**: the ability to learn from others; to understand and respect the needs, perspectives, and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving.
6	**Critical thinking competence**: the ability to question norms, practices, and opinions; to reflect on one's own values, perceptions, and actions; and to take a position in the sustainability discourse.
7	**Self-awareness competence**: the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.
8	**Integrated problem-solving competence**: the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive, and equitable solution options that promote sustainable development, integrating the previously mentioned competences.

The first five competences are based on the work by Wiek at al. (2011). One could argue that the eight competences, if stripped from the word sustainability which appears in some of them, are valid within any context and not solely to sustainability. Key words that sum up the eight key competences are collaboration, reflection, holistic thinking, and self-awareness. Such words generally permeate most university courses and programs and should therefore not constitute any major hindrance when considering sustainability as a specific topic. The challenge to a lecturer is to come up with relevant examples and cases where students can elaborate around sustainability issues in a natural and transparent context.

Lambrechts et al. (2013) analyzed the existing competence schemes of three programs within two Belgian universities in the fields of business management, office management, and applied information technology. The results of the analysis showed that competences for ESD related to responsibility and emotional intelligence were widely integrated, while competences for ESD dealing with system orientation, future orientation, personal commitment, and action taking were virtually absent.

Table 3. Pedagogical sustainability assessment activities (Stough et al., 2018)

Passive learning (summative)		**Active learning (formative)**	
In class	**Out of class**	**In class**	**Out of class**
Formal lectures	Guided city tours	Group discussions with reporting	Interviews
Guest lectures	Company visits	Questions	Internships
Research	Participation in roundtables/company stakeholder	Brainstorming	
Forum/discussion panels		Teaching-learning conversations	
Cases discussed by instructor		Cases processed by students	
Blended learning		Voting	
Online discussions		Simulation games	
Film screenings		Class discussions	
		Group work	
		Self-study	
		Project planning on computer	

Sustainable development goals

The United Nations have defined 17 sustainable development goals, SDG (UN, 2015). Ideally, the ESD at university level should touch upon all the 17 SDGs. This, however, could be difficult to achieve within a single course. More likely, they should be addressed at program level (or school level), if possible. Kestin et al. (2017) have presented a guide on how to get started with the SDGs on a university or higher education institution level. The guide 1) covers a summary of what the SDGs are, why universities are crucial for the achievement of the SDGs, and the significant benefits universities can gain from engaging with the SDGs, 2) provides an overview of how universities can contribute to implementing the SDGs through their core functions of education, research, operations and external leadership, 3) provides a step-by-step guide to help universities engage with the SDGs and in particular develop an institution-wide framework for supporting SDG implementation, and 4) offers practical guidance and tools to assist universities engage with the SDGs, including how to map existing activities, how to engage with stakeholders, and how to report on SDG contributions. Kopnina (2018) discusses how the SDGs are reflected upon within existing sustainability programs at a vocational college, and at the undergraduate and postgraduate university levels in The Netherlands. Within all three institutions Kopnina integrated lectures on sustainable development with specific emphasis on the SDGs. The presented case studies offer a brief summary of the curricula for the different Dutch programs that help address the 17 SDGs. The results indicate that the SDGs are mostly too anthropocentric, do not consider non-human species, and do not go far enough in addressing unsustainability.

Constructive alignment

As briefly outlined in the previous sections, if one as a lecturer or program manager has the intention to incorporate sustainability at university level, the ambition should be to reach as high as possible on the sustainability transition ladder (table 1). Most, or at least several, of the key competences in sustainability should be covered, if not within every single course, at least to some extent at program level.

The task requested in any university course is to constructively align the intended learning outcomes (ILO), with the teaching/learning activities (TLA) and the assessment tasks (AT), as described by Biggs and Tang (2011). Also, the TLAs should have a clear learning focus,

The sustainability transition within the SPE master's program is outlined in this paper by describing some possible measures regarding ILOs, TLAs and ATs applied to two of the program courses, i.e., IPC and IPRIC. The UNESCO sustainability key competences are also contemplated as are the sustainability development goals, at least to some extent.

ANALYSIS

First some results related to sustainability issues in higher education are presented followed by a description of the two courses and how they look today in regard to sustainability. In the Results section, the steps taken to incorporate sustainability in the courses are presented.

Industrial Placement Course (IPC)

The student, the host company and the university work out a suitable assignment together, based on the business's needs and opportunities and on the student's skills and experience. The assignment is then discussed and approved. Some examples of typical IPC student assignments at a company are:

- Take part in and contribute knowledge into ongoing project.
- Conduct a study of an ongoing production process.
- Try different kinds of practical work that are relevant to the student's education.
- Participate in professional development in the company based on the student's previous courses and experiences.

In continuation, the ILOs, TLAs and ATs are described and analyzed.
Intended Learning Outcomes

Table 4 outlines the intended learning outcomes (ILO) for the IPC. It can be noticed that one of the ILOs explicitly focus on sustainability.

Table 4. Intended learning outcomes in the IPC course

Knowledge and understanding (KU)
Demonstrate an understanding of the difference between the experience of practical work and the theoretical knowledge acquired earlier in the program
Competence and skills (CS)
Demonstrate the ability to apply the knowledge acquired through their education in professional work
Demonstrate the ability to describe, analyze and reflect on the results of their work experience and to present them orally and in writing to the client and at the university
Judgement and approach (JA)
Demonstrate the ability, based on experience with clients, to reflect on their need for knowledge and skills in professional practice
Demonstrate insight into their future professional role and the responsibility for ***sustainability*** that comes with it

Teaching/Learning Activities

The IPC consists of the following teaching/learning activities:

- An introductory seminar
- 3 lunch seminars on how to find a placement, how to write a CV and how to behave during a job interview
- 5 weeks of work at a company or organization

Assessment Tasks

The IPC consists of the following assessment tasks:

- Write a report that includes two parts; one where the student presents his/her activities in the company and one presenting the student's reflection of the activities in relation to the program, taken courses and personal competences
- Present the work activities and reflections in a seminar
- Oppose on another student's report and presentation

As can be observed, only one ILO explicitly addresses sustainability. As can also be observed, the ILO is not explicitly addressed during the TLAs or ATs. Furthermore, the ILOs are not constructively aligned in a good fashion with the TLAs and the ATs. One main obstacle is the fact that the course is mainly conducted outside of the university campus at a company or organization, which means that most activities are 'invisible' to the course manager. This poses a special challenge when aligning the course, especially when it comes to the TLAs as all of them currently take place outside of the university campus. Currently, all ILOs are assessed in the final report and during a final presentation.

Industrial Product Realization in Collaboration (IPRIC)

The course covers the different stages in the product realization process and provides a theoretical, organizational, and scientific framework both generically and specifically for the different master programs. The course includes the following topics:

- Content, working methods and environment conditions of the stages in the product realization process
- Relevant product development, industrial design, and information technology methods
- Group dynamics, leadership, and communication in the different stages of the product realization process
- Multicultural aspects of communication and work

As stated earlier, IPRIC is a common and mandatory course taken by all students in all the six master programs at the school of engineering, involving some 160 students. The master programs include a large proportion of foreign students, coming from all over the world, something that is touched upon in some of the intended learning outcomes. In continuation, the ILOs, TLAs and ATs of the IPRIC course are described and analyzed.

Intended Learning Outcomes

Table 5 outlines the intended learning outcomes (ILO) for the IPRIC course.

Table 5. Intended learning outcomes in the IPRIC course

Knowledge and understanding (KU)
Demonstrate comprehension of the content, working methods and environment conditions of the stages in the product realization process
Competence and skills (CS)
Demonstrate the ability to analyze different forms of leadership and group's dynamics
Demonstrate the ability to work in a multicultural work environment
Demonstrate the ability to complete a project in a collaboration and meet the pre-determined objectives of the project
Judgement and approach (JA)
Demonstrate the ability to value and reflect over the result of the project towards pre-determined objectives
Demonstrate an understanding of how different skills in the product realization process contributes to the entire process
Demonstrate an understanding of how personal and cultural differences contribute to the outcome of development work

Teaching/Learning Activities

The IPRIC course consists of the following teaching/learning activities:

- Seven lectures (teaching) directly followed by a related seminar (learning) conducted by six different lecturers from different departments at the school of engineering
- One workshop (teaching/learning)
- Six multi-cultural competence training opportunities (teaching/learning)
- A project developed by teams of students (learning)

Assessment Tasks

The IPRIC course consists of the following assessment tasks:

- A project developed by teams of students
- An assignment developed by teams of students

The project covers the following topics:

- The students form teams consisting of participants from the six different master programs and with diverse cultural backgrounds
- The teams develop a project around one of three possible problems (contributing with their own domain specific competences), e.g.
    - Smart lighting panels in classrooms
    - Smart lighting panel in open office spaces
    - Smart lighting panel in residential spaces
- The work is entered in individual logbooks including
    - Experiences while conducting the project
    - Group dynamics during the project
- A presentation of the results

The assignment (in form of written individual reports) covers the following topics:

- Experiences while conducting the project
- Group dynamics during the project
- The students' own contribution during the project
- Student reflections on multi-cultural teams during the project realization
    - Positive aspects, benefits – how did the students utilize them?
    - Negative aspects, challenges – how did the students overcome them?

An analysis of the project and the assignment with respect to the key sustainability competences results in that the project to greater degree touches upon the (4) Strategic, (5) Collaboration and (7) Self-awareness solving competences while the assignment mostly touches upon the (1) Systems thinking, (2) Anticipatory, (3) Normative, (6) Critical thinking and (8) Integrated problem-solving competences. As can also be observed, the project acts both as a TLA (explicit learning) and as an AT activity (but some learning will implicitly take place during the group work) while the assignment is mostly an AT activity (but some learning will implicitly take place during the reflections). Yet another observation is that the multi-cultural

group activities that take place during the development of the project act as a design experiment due to its iterative nature (Downing-Wilson et al., 2011). Furthermore, the teams also function as communities of learners due to the continuous discussions between the team members while they simultaneously assimilate the sustainability lingua franca through mutual appropriation (Downing-Wilson et al., 2011).

Regarding the constructive alignment between the ILOs, TLAs and ATs it should be noted that the TLAs provide the students with the necessary knowledge/learning experiences for them to be able to perform the ATs, thus forming a bridge between the ILOs and the ATs. The current ILO – AT alignment is outlined in table 6.

Table 6. Alignment ILO – AT

Intended Learning Outcomes	**Assessment Tasks**
Knowledge and understanding (KU)	
Demonstrate comprehension of the content, working methods and environment conditions of the stages in the product realization process	Project (Process)
Competence and skills (CS)	
Demonstrate the ability to analyze different forms of leadership and group's dynamics	Project (LGD) Assignment
Demonstrate the ability to work in a multicultural work environment	Project (MCT) Assignment
Demonstrate the ability to complete a project in a collaboration and meet the pre-determined objectives of the project	Project (Collaboration)
Judgement and approach (JA)	
Demonstrate the ability to value and reflect over the result of the project towards pre-determined objectives	Project (Implementation)
Demonstrate an understanding of how different skills in the product realization process contributes to the entire process	Project (Process)
Demonstrate an understanding of how personal and cultural differences contribute to the outcome of development work	Project (MCT) Assignment

LGD: Leadership and Group Dynamics, MCT: Multi-Cultural Teams

RESULTS

Industrial Placement Course (IPC)

The sustainability transition that is outlined in continuation is from stage 1 (no sustainability in the education) to stage 2 (education about sustainability). Stage 3 (education for sustainability) would be even more adequate and is briefly elaborated on at the end.

Regarding the currently taught and assessed competences coupled to sustainability, it could be argued that the only key competence that explicitly touches upon the learning outcome 'Demonstrate insight into their future professional role and the responsibility for *sustainability*

that comes with it' is the 'anticipatory competence'. The other key competences could be regarded as implicitly touched upon in IPC (as well as other courses in the SPE program). This, however, is not entirely satisfactory, especially if one strives to reach stage 3, and even more so stage 4, on the sustainability transition ladder.

The eight key competences previously described often rely on collaboration between different stakeholders and are considered formative in nature. They also promote a deep approach to learning (Biggs and Tang, 2011) which is essential from a life-long, self-induced learning perspective. As IPC is almost entirely developed at a company/organization, the course needs to prepare the students for these collaborative activities. The activities should preferably be conducted during the start of the SPE program in a course such as IPRIC, which is described further on.

'Improved' competences (stage 2)

The 'best' way to improve the competences would be to incorporate some collaborative activities focusing on sustainability in the beginning of the course. However, such activities could be regarded as bolt-on (see table 1). The best would thus be to incorporate new activities in the IPRIC course. Having stated that, the following activities could be considered in the IPC.

Teaching/Learning Activities

- Add an extra seminar in the beginning of the course imparted by an expert in sustainability, to make the students aware of what is expected from them during the stage at the company/organization.
- Have the students evaluate how sustainability is implemented at a company/organization and what pros and cons that can be observed from this implementation.

Assessment Tasks

- Explicitly request a special part in the report, as well as during the presentation, with a deeper analysis of sustainability issues handled by the company/organization.

'Improved' competences (stage 3)

To deepen the understanding of sustainability, some more costly activities (timewise) could be implemented.

Teaching/Learning Activities

- Add an extra seminar in the beginning of the course imparted by an expert in sustainability, to make the students aware about what is expected from them during the stage at the company/organization (same as for stage 2 to prepare for the other activities). This could possibly be left out if implemented in the IPRIC course, presented next.

- Have the students evaluate how sustainability is implemented at a company/organization through a number of interviews with key persons.

Assessment Tasks

- Explicitly request a special part in the report, as well as during the presentation, with a deeper analysis of sustainability issues handled by the company/organization.
- Have a separate discussion seminar, possibly right after the 'ordinary' presentations, where only the sustainability findings are discussed between the students.

Industrial Product Realization in Collaboration (IPRIC)

As can be observed, no ILO explicitly addresses sustainability, as compared to the IPC. This is (potentially) a drawback that could be circumvented by adding one (or possibly several) specific ILO(s), as in IPC, by modifying one or several of the ILOs or by explicitly adding some 'sustainability' activities within the project/assessment. The first two suggestions would make it possible to reach stage 2 (bolt-on) while the last suggestion would make it possible to reach stage 3 (build-in). A combination of the three suggestions could also be contemplated. Because of the nature of the IPRIC course and its multi-cultural aspects, it could even be argued that the name of the course could be modified to ***Sustainable*** *Industrial Product Realization in Collaboration*. Having stated that, in continuation are outlined some possible activities that could be incorporated in the IPRIC course, to improve the sustainability transition process to reach the higher stages of the sustainability transition ladder.

'Improved' competences (stage 2)

As could be observed, IPRIC is currently not explicitly contemplating sustainability at all, thus barely reaching stage 1. Like the IPC, a simple and straightforward approach is to introduce sustainability by adding a specifically designed seminar on sustainability.

Teaching/Learning Activities

- Add an extra seminar taught by an expert in sustainability to make the students aware of what is expected from them during the development of the project.

Assessment Tasks

- Explicitly request a specifically designed part in the report, as well as during the presentation, with a deeper analysis of sustainability issues within the project.

'Improved' competences (stage 3)

A more formative approach would be to make use of the inherent opportunities encountered within the course, such as collaborative activities and integrated problem-solving. By having the students reflecting upon economic, social, and environmental sustainability aspects during

the development of the project, all eight UNESCO key sustainability competences (KSC) would be touched upon, some of them to a greater extent:

1. Systems thinking competence (individual): would be developed (and assessed) in the assignment but to some extent also during the project.
2. Anticipatory competence (individual): would be developed (and assessed) in the assignment but to some extent also during the project.
3. Normative competence (individual): would be developed (and assessed) in the assignment but to some extent also during the project.
4. Strategic competence (group): would be developed (and assessed) during the project due to its multi-cultural nature but to some extent also during the assignment.
5. Collaboration competence (group): would be developed (and assessed) during the project due to its multi-cultural nature but to some extent also during the assignment.
6. Critical thinking competence (individual): would be developed (and assessed) in the assignment but to some extent also during the project.
7. Self-awareness competence (individual/group): would be developed (and assessed) during the project due to its multi-cultural nature but to some extent also during the assignment.
8. Integrated problem-solving competence (individual): would be developed (and assessed) in the assignment but to some extent also during the project.

In general, there should be a movement from instrumental to emancipatory teaching/learning/assessment activities (Wals et al., 2008), something that the key sustainability competences will bring about.

Teaching/Learning Activities

- Design specific activities that should be seamlessly incorporated in the lectures, seminars, multi-cultural competence development etc. An example of this could be to have the students reflect upon social sustainability from a multi-cultural perspective during the project development. This is a form of social learning activity where the students are learning by mirroring their own ideas, views, values, and perspectives with those of the others in the team (Wals, 2011). It is a fact that people in general, and students in specific, learn more from each other when they are different from one another than when they all think alike, but only when there exists a social consistency in the group. That is why the multi-cultural competence training opportunities are of special importance.
- Another possible activity that would incorporate environmental, economic, and to some degree societal sustainability would be to have the students evaluate the impact on sustainability by having them apply the new ISO 14008 standard to their projects (ISO 14008:2019). The standard specifies a methodological framework for the monetary valuation of environmental impacts and related environmental aspects. A paper on how this monetary valuation can take place was presented by Steen (2016). Environmental impacts include impacts on human health, and on the built and natural environment. Environmental aspects include releases and the use of natural resources. The standard specifically contributes to the sustainable development goal 11 (Sustainable cities and

communities) and 13 (Climate action). Three case studies presented in a report by Steen et al. (2018) could provide examples when creating a specific activity around this theme in the IPRIC course.

Several similar activities should be designed and incorporated into the course study guide. The details of these activities, however, are not further detailed in this paper.

Assessment Tasks

- Explicitly request a specifically designed part in the report, as well as during the presentation, with a deeper analysis of sustainability issues within the project taking into consideration the mainly group key sustainability competences, i.e. (4) Strategic, (5) Collaboration and (7) Self-awareness competences (formative, deep learning). The difference from stage 2 is that the written and oral reflections should be much more exhaustive, to be able to observe and assess the acquired key competences.
- In the assignment, the students should develop and reflect upon sustainability taking into consideration the mainly personal key sustainability competences, i.e. (1) Systems thinking, (2) Anticipatory, (3) Normative, (6) Critical thinking and (8) Integrated problem-solving competences (formative, deep learning). The difference from stage 2 is that the written and oral reflections should be much more exhaustive, to be able to observe and assess the acquired key competences.
- Have a separate discussion seminar, possibly right after the 'ordinary' presentations, where only the sustainability findings are discussed between the different teams.

Table 7 illustrates how the constructive alignment could look like in order to reach stage 3 (build-in) on the sustainability transition ladder.

DISCUSSION

As can be observed in the presentation of the two courses, i.e., IPC and IPRIC, the latter appears to offer the biggest opportunities to incorporate activities that will improve the sustainability awareness among the SPE students. An additional advantage is that the IPRIC course happens to be the very first course taken by the students, thus making it possible to establish the sustainability compass for the remainder of the master programs in general and the SPE program in specific. Thus, in theory, it should be less challenging to incorporate sustainability activities in the IPRIC course. This is the reason why IPC could, and should, be modified as far as possible, together with other courses within the SPE program, to be able to possibly reach stage 4 on the sustainability transition ladder (table 1). The final goal is to make the students action competent in sustainability (Bruun-Jensen and Schnack, 1997), i.e., that they have the means to independently, or in a team, act on sustainability issues, whether they be environmental, economic, or societal.

Table 7. Alignment of ILO – TLA – AT – KSC

ILO	TLA	AT	KSC
KU: Demonstrate comprehension of the content, working methods and environment conditions of the stages in the product realization process	Lecture Seminar Project	Project (Process)	4, 5, 7
CS: Demonstrate the ability to analyze different forms of leadership and group's dynamics	Workshop Multi-cultural comp. Project Assignment	Project (LGD) Assignment	1, 2, 3, 4, 5, 6, 7, 8
CS: Demonstrate the ability to work in a multicultural work environment	Workshop Multi-cultural comp. Project Assignment	Project (MCT) Assignment	1, 2, 3, 4, 5, 6, 7, 8
CS: Demonstrate the ability to complete a project in a collaboration and meet the pre-determined objectives of the project	Workshop Multi-cultural comp. Project	Project (Collaboration)	4, 5, 7
JA: Demonstrate the ability to value and reflect over the result of the project towards pre-determined objectives	Project	Project (Implementation)	4, 5, 7
JA: Demonstrate an understanding of how different skills in the product realization process contributes to the entire process	Workshop Multi-cultural comp. Project	Project (Process)	4, 5, 7
JA: Demonstrate an understanding of how personal and cultural differences contribute to the outcome of development work	Workshop Multi-cultural comp. Project Assignment	Project (MCT) Assignment	1, 2, 3, 4, 5, 6, 7, 8

One would assume that the more courses with a sustainability context the better and that the optimum would be to have sustainability permeate each and every course within a university program. This assumption, however, was disproved by Fisher and McAdams (2015) whose results indicate that the type of sustainability courses taken, not the number of courses, significantly impacts students' conceptions of sustainability. Courses that have an integrated and direct emphasis on sustainability – and its literature – seem to cause students to have the most expanded conception of sustainability. The results by Fisher and McAdams also indicate that gender, race, and age appear to play a role in the way in which students perceive sustainability. Hence, a multi-cultural, multi-disciplinary and holistic course like IPRIC seems to be an excellent choice to introduce sustainability.

Similar results to those presented by Fisher and McAdams, that courses that have an integrated and direct emphasis on sustainability cause the students to have the most expanded conception of sustainability, were presented in a study by Jung et al. (2019). The study examined sustainable behaviors and social responsibility perceptions among U.S. university students enrolled in construction-related courses. To measure the effectiveness of sustainable construction courses and learning outcomes, the study categorized students based on their experience of taking such course(s) and compared the results in terms of their level of environmental concerns, objective and subjective knowledge, and sustainable consumer behaviors. The authors' initial hypothesis was that students who had taken a course on sustainability would have greater levels of environmental concern and be more engaged in performing sustainable consumer behaviors. However, the results were quite the opposite;

environmental concern and sustainable consumer behavior scores were significantly lower among students who had taken the course than among those who had not. Regarding the results of the two types of knowledge, both objective and subjective knowledge scores were relatively low. There was no difference between the two groups in the objective knowledge scores and unexpectedly, subjective knowledge scores were significantly lower among students who had taken the course as compared to those who had not. This indicated that those students who had not been engaged in sustainability education felt more familiar with the topic than those who had the opportunity to learn about the subject. Strange as it may sound, the complexity of understanding sustainability concepts may have caused students to lose confidence and familiarity about the topic. The results indicate that it is an extremely difficult and delicate problem to incorporate sustainability in university education in such a way that there will be a positive and observable outcome of the studies. Thus, much time and effort must be spent on the careful design of the courses and the program curriculum if an engineering program strives to reach the highest levels of the CDIO optional standard 1.

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