INTEGRATING GENDER EQUALITY, DIVERSITY, AND EQUAL CONDITIONS, IN ENGINEERING EDUCATION

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ABSTRACT

In engineering education, as well as in the society at large, there is an increasing focus on sustainability and sustainable development. The CDIO Standards and the CDIO Syllabus has been substantially updated to meet and drive these changes. Progressive engineering programs have by now made substantial progress in integrating environmental aspects of sustainability and sustainable development into the curriculum. However, the integration of social aspects is generally considered to be more difficult and is therefore lagging behind. This explorative research paper provides insights in efforts to integrate elements of gender equality, diversity and equal conditions (GDE) in three courses on bachelor's, master's, and doctoral level. The focus is on the development and implementation of reflective assignments, where a theoretical framework is used for characterizing different levels of reflection. The work has been performed by use of an action research approach that has involved close dialogue and collaboration between researchers, pedagogic developers, teachers, students, and education leaders. The paper hereby contributes with multiple perspectives on GDE integration, and significant challenges are discussed. The paper also contributes with concrete examples of reflective assignments, learning activities, and literature that can be useful also in other contexts.

KEYWORDS

Gender equality, Diversity, Equal conditions, Sustainable development, Reflective writing, Optional standards for sustainable development, Standards: 1, 2, 3, 7, 11

INTRODUCTION

With the increasing awareness of the urgent need for societal transformations to ensure sustainable living conditions for ourselves and future generations (e.g. UN 2015, IPCC 2018,

WWF 2020), and the crucial role of engineering in such transformations (e.g. UNESCO 2021), there is an increasing focus on improving the future relevance of engineering education with regards to sustainable development (e.g. Thürer et al, 2018; Fenner & Morgan, 2021). The updated CDIO Standards 3.0 and CDIO Syllabus 3.0 have established sustainable development as central in the CDIO concept and the new "optional" CDIO Standard for Sustainable Development provides extended objectives and guidance (Malmqvist et al, 2020a&b; Rosén et al, 2021; Malmqvist et al, 2022).

Since 2006 sustainable development has been explicit in the overarching learning objectives and degree requirements for engineering degrees in the Swedish Higher Education Ordinance. The KTH Royal Institute of Technology has had institution-wide objectives and systematic approaches for integrating sustainable development in the engineering education programs for more than 10 years. Evaluation of the current status shows clear progression regarding general aspects of sustainability and environmental sustainability whereas the integration of social sustainability, and therewith related issues such as gender equality, is lagging behind (Hermansson & Rosén, 2021).

In 2016, the Swedish Government commissioned all Swedish universities to develop plans for gender mainstreaming in order to contribute to achieving the national gender equality policy goals (Nationella sekretariatet för genusforskning, 2016). KTH developed a plan for *Gender equality*, *Diversity* and *Equal conditions* (GDE), which includes the following education related goals: 1) increase knowledge and awareness of GDE throughout KTH in order to be able to challenge and change unequal structures and cultures; 2) the integration of knowledge about GDE must be done both in terms of content and in practical action in all education programs; 3) increased awareness of GDE must be related to social sustainability and values in a comprehensive way (KTH, 2017). Further, in the KTH Development plan for 2018-2023, it is stated that gender perspectives must be integrated into all study and research programs (KTH, 2018), and KTH's new sustainability objectives for education for the period 2021-2025 highlights *equality* as an integral part of sustainable development (KTH, 2021).

However, as emphasized by Fitzpatrick (2017), integrating social aspects of sustainability is not an easy task for engineering educators, partly because it is perceived as "outside their discipline and comfort zone". Edvardsson et al (2015) came to similar conclusions as they found that engineering faculty had difficulties implementing issues of social sustainability in the curriculum, partly explained by the fact that faculty members found the concept of social sustainability hard to grasp. Further, the normative aspects of social issues can be challenging to handle, both when complex discussions emerge in the classroom and in assessment and grading.

This paper provides insights in efforts to integrate GDE in three courses on bachelor's, master's, and doctoral level, with particular focus on the development and implementation of reflective assignments. The work has been performed by use of an action research approach that has involved close dialogue and collaboration between researchers, pedagogic developers, teachers, students, and education leaders. The paper is outlined as follows: First, an overview of the concept of reflections is presented and related literature is briefly reviewed. Next, the research setup and approach are presented, followed by a description of three case studies including an overview of the status before this study, the interventions conducted through the study, and the observations and reflections made along and after the interventions. Then follows a discussion of the findings, concluding remarks and future work.

STUDENT REFLECTIONS

The focus of the project presented in this paper was on developing and implementing reflective assignments that combines learning activities and assessment, as means for integrating GDE in the three course modules. The aim of student reflections, in general, is to support students in their learning. For example, Boud and Walker (1985, in Kember, 1999, p. 22) state that "reflection in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations." Rogers (2001, p. 41) argues that "the intent of reflection is to integrate the understanding gained into one's experience in order to enable better choices or actions in the future". Moreover, student reflection has the potential to support active learning as the students need to be actively involved in the subject content or problem, contextualize it with their own experience, and thereby construct meaning and learning (Freeman et al., 2014; Prince, 2004). Hence, reflections can be used in teaching and learning as means for students to elaborate on a particular field of knowledge with the intention for them to learn and widen their perspectives, with the overall goal to support students to make better future decisions.

In their work on characterizing student reflections, Hatton and Smith (1995) identified four different types, or levels, of reflective texts: (I) descriptive writing, (II) descriptive reflection, (III) dialogic reflection, and (IV) critical reflection, as presented in Table 1. In order to support the students to develop their writing beyond the descriptive type, these characterizations can be used to clarify what the students need to consider when writing reflections. This method has been used in several engineering education programs to support students' capacity to reflect (Cajander et al, 2011; Kann & Magnell, 2013). Hence, the use of reflections, including this type of scaffolding, seemed to be a feasible approach when designing the assessment tasks.

Table 1. Different levels of reflection (based on Hatton & Smith, 1995)

Level of reflection	Characteristic
I Descriptive writing	Description of events, not reflective
II Descriptive reflection	Contains reasoning and argumentation in relation to the theme
III Dialogic reflection	Contains alternative actions and their consequences
IV Critical reflection	Includes multiple, possibly contradictory, perspectives with consideration to broader societal contexts

Some common challenges around reflection include different understandings, thoughtless reflection, and concerns around ethics. To deal with these challenges, Bek (2012), Grossman (2009), and Hatton and Smith (1995), all argue that clear guidance is essential when students are asked to write reflective texts. Without such scaffolding, there is a risk that the students write descriptive rather than reflective texts (e.g., Grossman, 2009).

THREE CASES OF ACTION RESEARCH

The work presented in this paper was conducted using an action research approach that involved close dialogue and collaboration between three education researchers/pedagogic developers, two Deans of Education who are also active as teachers, one additional teacher,

and several students. In action research, the aim is twofold and thus includes both knowledge production and achievement of change and improvements of different kinds (Brannick & Coghlan, 2007; Cohen et al, 2011). The action research process contains a *spiral of self-reflection* including *planning*, *acting*, *observing*, and *reflecting*, which is repeated in several iterations (Kemmis et al, 2014, p. 18). Three different cases are included in this study and each case is described in terms of the *status* of GDE integration before the study, the *interventions* performed through the study, and *observations and reflections* on the outcome of the interventions. Data was generated by planning learning activities, observing lectures, conducting interviews and a survey, and reading students' individual assignments. Other sources of data include the reflections of the teachers and researchers. Based on the findings, *further development* of learning activities, ILOs, assessment and grading, are suggested.

Case 1: A module on master's level

Status before this study

The first case concerns the integration of GDE in the master's level course *Research Methodology in Engineering Mechanics*. Already in the autumn 2016, a two-hour lecture on GDE was included in this course (Altimira & Casanueva, 2017). The lecture introduces concepts such as stereotype threat, homo-sociality, and implicit discrimination, and demonstrates that research methodologies are not inherently neutral or unbiased by showcasing research projects and innovations that failed for not considering diversity. The lecture also includes a discussion on how to recognize our unconscious biases, acknowledge them, and find strategies that mitigate their impact in our decisions. The teacher has a background in Mechanical Engineering and does not have any formal education related to GDE except for various standalone seminars on the topic.

Interventions

The aim of the intervention in this course was to establish a more comprehensive GDE module, not only consisting of a learning activity in terms of the lecture, but also including learning objectives and assessment, to enable constructive alignment and enhanced student learning. The intervention included development of a reflective assignment that is intended to complement the lecture with additional learning activities, reading and related assessment. The assignment encompassed reading the report "Gendered Innovations" (EC 2020), choosing one of the case studies in the report, and then writing a text of at least 500 words, briefly reviewing the chosen case and "*reflect upon (i.e., discuss and build on arguments from the text to illustrate) how consideration of equality, gender equality, diversity and inclusion among engineers can influence and/or contribute to research, innovation, and societal development. Identify two examples of such influence/contribution*." This assignment hence concerns reflections on level III and IV according to Table 1.

The reflective assignment was tentatively developed by two of the researchers in dialogue with the course teacher and the Dean of Education. To also include the students in the development of the full GDE module, this assignment was not mandatory the first course round it was implemented, but instead students were encouraged to do and submit the assignment voluntarily, both for their own learning but also to help developing the module for future course offerings. In total six students chose to do and submit the assignment.

Observations and reflections

To evaluate the first round of implementation of this new reflective assignment, and plan for further development, data was collected by the researchers observing the lecture, reading the students' assignments, conducting semi-structured interviews with four students (one group interview, I1, and one individual, I2), and a very brief questionnaire survey. The data collection was further complemented by the teacher's and researchers' reflections. We will here highlight some of the more significant findings that will be of value for the continuation of this study as well as for the integration of GDE in engineering education in general.

From observing the lecture, it could be seen that the students did not engage a lot in the discussions. Our assumption is that students may think that this can be a sensitive area where they do not feel comfortable and that might lead to polemic discussions. The teacher has perceived a substantial evolution of the students' basic GDE knowledge through the five years the lecture has been included in the course. This could arguably be attributed to his own learning that enables better evaluation of their knowledge and thus improves his interactions with the students during the lecture.

The few submitted assignments were of high quality. Hence, the suggested assessment task seemed to work as planned. In the interviews, the students expressed appreciation of the reading in the assignment, in particular the connection to research in engineering disciplines, but they would have preferred to not have as many cases to choose from. To improve the module, they also suggested that the text should be read *before* the lecture and that the teacher should focus on some of the cases in the lecture (I1, I2), thereby making the different parts of the module more aligned. The students also appreciated reflecting on consequences of considering, or not considering, aspects of GDE in research, innovation and societal development (I1). Some of them would have welcomed additional reading in order to include multiple perspectives (I1). Some students also suggested to complement the module further with some kind of group discussion in which the students, in smaller groups, can discuss and dig deeper into GDE (I1, I2).

Further development

This course module may be improved by enhancing the constructive alignment and thus aligning the teaching and learning activity and the assessment. As suggested by the students, the learning activity may include reading the report "Gendered Innovation" prior to the lecture, the teacher may include parts of the main message in the report in the lecture and also add group discussions in which the students will elaborate on consequences of considering, or not considering, GDE in research and how that may influence research, innovation and societal development. Intended learning outcomes also need to be developed.

Case 2: A module on bachelor's level

Status before this study

The second case is an already established module in the course *Management of Knowledge-Intensive Organizations* on bachelor's level in a computer science program. One of the learning objectives in this course stipulates that the student should be able to describe and critically discuss how knowledge-intensive activities can and should take social sustainability into account. The module includes learning activities and material in terms of a pre-recorded lecture by researchers specialized on gender and equality in industrial organizations, and recommended reading. The module was assessed by an individual reflective assignment where the students should write a text on "*how social categories both form the basis for*

creating inclusion and exclusion, and for stereotypes, prejudices and discrimination; what consequences equality and/or inequality can have for a knowledge-intensive organization; and how a company should go about to achieve equality, diversity and equal conditions."

Interventions

The intervention in this course module included the researchers revising parts of the reflective assignment together with the teacher, aiming to clarify what the students should reflect upon, and adding the report "Diversity wins" (Hunt et al 2020) as reading. The revised reflective assignment was as follows: *"Reflect upon what consequences inequality and gender inequality may have in a knowledge-intensive organization, base your reflections on the lecture and the reading, build on examples from the report 'Diversity wins'",* and "*reflect upon how a company, preferably a potential employer, can accomplish gender equality, diversity, and equal opportunities, i.e., discuss different methods and processes".* This reflective assignment can be categorized as being on level II-III according to Table 1.

Observations and reflections

The evaluation of this module was based on teachers' observations of the students' submitted assignments, a semi-structured interview with one student, and the teachers' and researchers' reflections. We will here highlight some perspectives that are complementing the insights from the master's level module.

In the submitted assignments, several of the students acknowledged that the video lecture was very useful and interesting, focusing both on subjects they could easily relate to (inclusion and exclusion) and their own education at KTH. The students also emphasized that the report "Diversity wins" displayed a lot of interesting statistics.

The submitted assignments clearly showed that the students had gained a lot of knowledge from the video lectures and recommended reading. Most of the students were in the assignment able to integrate this knowledge into their reasoning on consequences of equality and inequality in knowledge-intensive organizations, and how the organizations can handle this. It should be noted that students in this program are used to writing reflective texts and, consequently, the assignment was not considered to be challenging.

In the interview, the participating student argued that an exercise that increases awareness of how people are discriminated would have been welcome, but also reflected upon the risk for students feeling uncomfortable in such exercises, if they are required to be personal and share their own experiences (I3).

Further development

This module may be improved by adding group discussions in which the students can elaborate on consequences of inequality and gender inequality in organizations before they submit the assignment.

Case 3: A module on doctoral level

Status before this study

The third case considers the establishment of a new GDE module in a mandatory course on sustainability for the doctoral program in *Technology and health*. The course consists of a series of half-day workshops aiming at contributing to an overall orientation about the different

research areas included in the PhD program and development of necessary skills. One of the intended learning outcomes of the course was for the PhD student to be able to: “reflect on what the concept of sustainable development can mean in their own PhD project, as well as in Technology and Health, based on social, economic and ecological aspects”.

Intervention

The intervention in this case concerned development and implementation of a completely new GDE module, consisting of a workshop and a reflective assignment, with focus to raise awareness about GDE among the PhD students. The workshop was planned and held by GDE experts, whereas the assessment was to be done by the examiner of the course. The workshop started with a short introductory lecture to GDE. After the lecture, the students did a group assignment about discrimination legislation. The workshop also included a role play (*Privilege walk).* Finally, the students discussed in pairs in what ways GDE can be integrated in their area of research, and in what ways GDE issues could be taken more into account in their work environment. In the individual reflective assignment, the students were asked to: 1) *Reflect on how, at least two, shortcomings in gender equality, diversity and equal conditions are expressed in your academic environment, and on your own role in creating an inclusive environment,* and 2) *Reflect on how your PhD project, as well as the fields of Technology and Health in general, benefit from integrating/considering GDE, and how these fields in turn can contribute to GDE.* This assignment hence concerns reflections on level I, II and III according to Table 1.

Observations and reflections

The evaluation of this module was based on interviews with participating PhD students (I4, I5), the workshop leader, the course responsible, and the researchers’ reflections. We will here highlight some perspectives that are complementing the insights from the master’s and bachelor’s level modules.

The course responsible was satisfied with the workshop. However, the interviewed PhD students responded somewhat critically, not for including GDE in the course, but on how it was implemented in their program, primarily because it was considered superficial (I4, I5). They suggested that it would be better if GDE was included in the mandatory courses on ethics and theory of science, and not only as a workshop. They also expressed preferences that someone with GDE expertise should lead the discussions together with a teacher within the engineering discipline.

The informants stated that the assignment did not contribute much to learning, particularly not on how to integrate GDE perspectives in their own research. One informant suggested that it would have been interesting to discuss the literature a bit more during the seminar, both in small groups and with whole class (I5). Another suggestion for the learning activity was to implement a wicked problem approach, “I liked the 'dilemmas' format from the sustainability seminar better than the group exercises in the gender and diversity seminar - we discussed how different sustainability goals might conflict with each other. I think it could be interesting to do a similar exercise with gender and diversity” (I5).

Further development

The module and its learning activities and assessment could be more integrated and thus connect more strongly to the students’ research. The reflective assignment could also be

revised to encompass critical reflection in which the PhD students are required to consider consequences of GDE, and lack of GDE, in their research and the broader societal consequences. This integration may be developed together with the PhD students as they are experts in their own research fields and on their needs. They may also have knowledge that goes further than the teachers'.

DISCUSSION

As described, the modules on bachelor's, master's and doctoral level differ: the first contained a lecture followed by a voluntary individual reflective assignment; the second contained online material, literature and an individual reflective assignment; and the third was mandatory and contained an introduction lecture, group discussions and exercises, reading, and an individual reflective assignment. On an overall level, all respondents emphasized that they appreciate the initiative to enhance GDE in education. Several of them, however, had previous knowledge and interest in the topic and stated that they did not learn much new and emphasized the importance of providing an interesting learning activity to all students, regardless of their previous level of knowledge. Moreover, the interviews and the survey indicate that there are several challenges involved in integrating GDE in engineering education.

One issue that we have identified considers the scope of these kinds of modules: should it be broad to provide a general overview and cover numerous aspects of gender, ethnicity, religion, etc., *or* deep, and should it in addition to knowledge also develop skills and attitudes? The students we interviewed seem to have found the modules to be somewhat superficial and too broad. Instead, they seem to prefer a deeper approach where they also get tools for handling and improving inequalities in working life and, for the PhD students, in their research. Based on these findings, we recommend focusing on those students that already have some GDE knowledge letting the other students work a bit harder to catch up.

Another question concerns who should be teaching; should it be a regular engineering teacher *or* a GDE expert? The interviewed students seem to prefer GDE experts. However, relying on external experts is costly and will most probably result in weaker integration with the specific subject or discipline. If possible, it could be good to both involve a GDE expert who can ensure depth and is more comfortable with facilitating value-related discussions and a regular engineering teacher who can contextualize GDE in the engineering subject and discipline, at least in early stages allowing the regular teacher to develop GDE knowledge and then gradually becoming confident (e.g., Fitzpatrick, 2017). Teaching GDE is difficult for teachers who have neither GDE knowledge nor tools to analyze their teaching and course content from a GDE perspective. Now, however, all programs at KTH must integrate elements of GDE for students to be able to contribute to a more sustainable and equal world. The proposal to use reflective assignments as a method for learning, is aiming to lower the threshold and provide support. However, reflection is a learning activity that may be new for many regular engineering teachers, where teaching often consists of lectures, labs and exams, and less often of (reflection) seminars. It requires courage and creativity from teachers and course leaders, and the three programs in this study have approached it differently in how they have set up the GDE modules. The role of the students should also be emphasized, where the teacher by taking a learning facilitator role rather than a content expert role, can invite the students as co-creators of the GDE integration. Our hope is that everyone who is involved in teaching and education in various ways can, regardless of the degree of GDE competences, contribute to integrating GDE in the education so that students can learn for a sustainable world.

The aim of this paper was primarily to share experiences from the development of course modules integrating GDE in two engineering programs and one doctoral program. The primary focus was put on the reflective assignments, i.e., the assessment, and the results of the study show that the proposed reflective assignments seem to have worked as intended. For the reflective assignments to become "intellectual and affective activities" leading to "new understandings" (Boud and Walker, 1985, in Kember et al, 1999, p. 22) and "better choices or actions in the future" (Rogers 2001, p. 41), we recommend including group discussions in GDE related teaching and learning activities. Hence, a missing ingredient to enhance the learning about GDE is a structured seminar. This missing link point to the importance of constructive alignment (Biggs, 1999) and the need for focusing on what the students should do to reach the ILOs, for example by including learning activities in which the students can actively work on and discuss their reflective texts.

CONCLUDING REMARKS AND FUTURE WORK

The paper has given multiple perspectives that contribute to the understanding of how to integrate sustainability and sustainable development in general, and social aspects of sustainability and GDE in particular, in engineering programs. The paper also contributes with concrete examples of reflective assignments, learning activities, and literature that can be useful also in other contexts. The presented course developments and establishment of reflective assignments, as well as the applied action research approach, are concluded to be feasible. There are however opportunities and needs for further development where additional cycles of action research, including *planning*, *acting*, *observing*, and *reflecting* (Kemmis et al, 2014), could be conducted and more data generated for enhanced understanding and evidence. The studied cases are not only at different levels, but they are also in different subjects, which may affect whether reflection as a method is embraced as there may be different teaching traditions in the different disciplines. Additional trials in courses across various engineering disciplines, interviews with students, and discussions with faculty members, need to be conducted in order to further develop all included aspects and to support the development of GDE integration in engineering education programs for a sustainable future.

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