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INTRODUCTION

Development of engineering skills and competences other than the professional discipline and knowledge-specific are considered important when educating engineers. Generic competences such as communication, presentation and teamwork are considered important of both graduated and employers when new engineers at master level from DTU (Technical University of Denmark) are starting their first job [1]. Instead of teaching generic engineering and personal competences in specific courses, they are integrated into existing courses, so the students can relate to their own discipline while learning the generic competences needed for working as an engineer. Thus, learning objectives for many courses also include generic requirements the students should learn during the course.

A research based course in Arctic Technology with field work in Greenland has been offered in various forms at DTU since the late 1990'ties. Students work with their own small research projects and in the first years the course was offered, the projects were mainly within civil and environmental engineering. DTU is presently offering 28 Master programmes and students from all programmes can choose the course, which has broadened the topics of the course to also covering for instance acoustic engineering, electrical engineering, sustainable energy and resource management. The course is popular with the students, since it's offering both a unique chance to visit Greenland and also doing field work. Many generic engineering and personal

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competences are developed when working with research based problems and when executing field work.

This paper describes and reflects on the experiences of teaching, motivating the students and assessing such a cross-disciplinary course. The paper focuses on the results and experiences of the course in 2013, when changes in the course such as peer-group work and article writing was introduced to further enhance the researched based teaching style.

1 COURSE BACKGROUND

1.1 Course description

The course “Arctic Technology” is a 15 ECTS elective course at master level which run over three semesters; spring, a 3-week field work period in August in Greenland and the autumn semester. The course is taught at Centre of Arctic Technology (ARTEK) at DTU Civil Engineering. ARTEKs main fields of research are within infrastructure, energy production and environmental engineering, aiming at developing engineering technology for and with the local Arctic community. ARTEK has facilities in Sisimiut, Greenland, which are used in the field work period.

The overall goal of the course is that students learn how to plan, execute and report field work in the Arctic, more specifically in Greenland. The learning objectives are developed in accordance to Blooms taxonomy [2] and are generically focussed rather than subject specific, to be able to assess all the students. A student who has met the objectives of this course will be able to:

- Investigate and document state-of-the-art concerning a chosen subject in Arctic context
- Find and use relevant technical information
- Demonstrate insight into other Arctic issues than one's own specialist area
- Argue based on cultural and social insight
- Plan and accomplish a fieldwork in the Arctic
- Suggest, assess and choose methods in relation to objectives
- Evaluate results critically
- Analyse and impart results in a meaningful way
- Summarise own and others results
- Write an article

In 2013, 20 students were registered for the course and in 2012, 37 students were registered. Students can also write their BSc or MSc thesis in the same context and 12 and 3 students did this in 2013 and 2012 respectively. The thesis students are following the spring and field work structure as the students registered for the course, the main difference is the reporting in the autumn semester and a final defence of the thesis instead of an oral exam. This paper is mainly focussing on the students registered for the course.

The students work with their own project (individually or 2 students per group), which they choose in the early spring. The origin of their projects is either proposed by Greenlandic stakeholders, a smaller part of a larger current research project or a project the students is defining themselves, with the acceptance of an ARTEK affiliated supervisor. In this way, almost any engineering discipline can be covered by the course, as long as it has relevance to Greenland. All students have a (different) *subject supervisor*, who is supervising and giving feedback on the scientific subject. The course responsible (the corresponding author of this paper) is coordinating all the different activities and the field work period and is also *process supervisor*, i.e. responsible for guiding and giving feedback on the generic parts of the projects.

1.2 Course challenges

There are three special challenges for the students during the course:
1) Why they should engage in other topics than their own specialist subject

2) To keep the motivation and appropriate working level throughout the year
3) To be able to navigate between the project and process supervisor

For the course responsible/process supervisor it is a challenge to ensure that all the students get the same amount and quality of feedback and supervision, since many project supervisors are involved.

2 TECHING METHODS

Teaching generic competences in engineering involves considerations about learning and development of competences among students, e.g. how the choice of teaching methods create the context in which the engineering students learn and how the teaching design interrelates and facilitates the learning of generic competences [3]. Preparing the students for and letting them act as engineers in the local Greenlandic community is a good setting for the development of generic competences to become a natural and integrated part of the course. This will also foster the students to identify themselves as engineers and to meet the expectations from stakeholders in society, which can be challenging in the present educational systems [4]. Developing generic competences is also closely related to the formation of the identity of an engineer [3]. Since the Greenlandic community is so small, the students get directly in contact to the management level of the stakeholders (municipality, government, private companies, fish industry) and have to be able to navigate and relate also to different cultural conceptions. The student's work has a high value to the Greenlandic community and this represents something quite unique in engineering education; student work can be used as decision tools for the stakeholders. Throughout this course varying teaching activities such as lectures, assignments, individual project work, supervision meetings with supervisors, peer group work and field work are used to facilitate and support learning of both technical and generic competences. Focus for all teaching activities is to support active learning, which is directly linked to research-based learning.

2.1 Spring semester

The ideas behind planning this course are to give the students the necessary tools to be able to do a research based project in Greenland. These tools are given in the spring as lecture with introductory knowledge about the Arctic/Greenland within different subjects, how and where to search for literature, how to present the research (orally, poster, article) and how to peer assess (review). There is also allocated time for the students to prepare their projects though assignments and together with their subject supervisors to be ready for the fieldwork in the summer. Important tasks for the students are to identify project relevant aims and scope by writing a project definition. Such an approach has been also been presented by Hansen and Lenau [5], where students are working with different cases and the learning objectives are kept generic to secure the constructive alignment regardless of the case subject The spring semester ends by a poster session where all the students are presenting their projects to each other.

2.2 3-weeks field period

The field work can consist of interviews, collecting samples or data or field measurements, observations etc. according to the project. The students are requested to do the field work themselves, but there will be supervisors (not necessarily their subject supervisor) in Greenland and also technical staff available. In the field work, the students meet local experts outside of the university, who introduce and discuss with the students about the different challenges and problems in the local Greenlandic community. The students are also presenting their projects and the results in public meetings. This coupling to real-life situations is very motivating for active learning for students [6].

2.3 Autumn semester

In the autumn semester there is primarily work with the student's own project and reporting in form of an article. In the autumn, project work could be running experiments and analysis on collected samples, modelling of data collected or treatment of observations, measurements and analysis results. Students are expected to use self-assessment and their subject supervisor for feedback on the scientific level and progression of their project. A review process for the final article, including peer-revision, initiated by the course responsible, was offered to support the process of article writing.

2.4 Using peer-assessment for motivation

Peer-assessment is considered a powerful tool for learning and provides increased understanding of the learning content, helps develop assessment and constructive criticism skills, promotes critical thinking and allows reflection on one's own performance [7, 8]. Students also pay attention to feedback given to them which has a social dimension [7]. In previous years, the students have been working isolated with their projects and often lacking important information and knowledge about the situation in Greenland, even if lectures were given about different subjects. In 2013 peer-groups were introduced for the students should help asses and motivate each other throughout the year. Formation of the peer groups (5-6 students per group) were done by the students themselves, following a few requirements:

- 1 student with experience in article writing (if there are any)
- 1 student speaking Danish (important for finding information on Greenlandic webpages not available in English)
- At least 3 different subjects

The tasks of the peer-groups were:

1. Required: give feedback on posters and twice on the articles (before and after fieldwork)
2. Suggested: help/motivation/discussion of projects prior to/during/after fieldwork, feedback on final article before hand-in, pre-presentations before final exam

2.5 Assessment

The summative assessment was based on the poster, final article and also the oral presentation of the project and article at the end of the semesters. A grade was not directly given for the poster presentation, to leave room for improvement for the final article. Formative assessment was made throughout the course by observation and discussions in the class and with supervisors/course responsible, through feedback from the subject supervisors as well as the peer-groups.

The intention of the summative assessment was to introduce the students to outcomes related to research (posters, articles, and presentations) and to find out if they achieved the learning objectives. Alignment between the learning objectives, teaching methods and assessment is a powerful tool when developing generic competences and making it worthwhile for the students to participate in the different teaching activities [9].

3 RESULTS AND DISCUSSION

3.1 The students

At the beginning of the course a pre-test was given, 30 students (both course and thesis students) participated and the test revealed their expected different background and scientific interest. The students for the course in 2013 consisted of 7 nationalities, 11 different study programmes and at MSc, BSc and BEng level. After the first lecture, a few more students joined the course, as they were recommended it by friends and some dropped the course, because they could not find a relevant project.

The students were asked directly which competences they expected to get from the course and what their motivation for taking the course was. For the motivation and expected learning from the course it was quite clear from the pre-test that the students were motivated by personal interest of going to Greenland and to learn something about their subject in the Arctic. Generally, the impression is that the students are highly motivated for this course which facilitates learning but are focussed on their own subject. The answers to which competences they expected to get from the course is seen as the generic competences in table 1. The list of generic competences was much shorter than what they expect to learn subject specific (not shown). Some students also answered "hiking and getting new friends". Even if these are not necessarily considered important engineering competences, the social dimension is very relevant for the learning and motivation, especially for the students to feel safe and see each other act in different roles as engineers [3]. Having a dynamic and relaxed group during the fieldwork has been observed in previous years to strongly influence the success of the student's fieldwork output.

Table 1. Student answers to expected generic competences to be achieved during the course

Take measurements	Write an article
Broader knowledge about Greenland	Plan my own project
Experience with field work	Teamwork
Do laboratory work	Work in another culture
Conduct research	Develop myself socially and cross-disciplinary
Do fieldwork	Take responsibility of own work
Getting confidence	Experience another culture

3.2 Feedback and peer group during the course

The pre-test showed that only a few students had tried to write an article previously. Thus, a review process for the articles was offered to the students, as well as a lecture with tips on how to write an article. There were two hand-ins for draft articles; one by the end of the spring semester, which should include the introduction, aim and materials and methods. The second hand-in was in the middle of the autumn semester, where the students should give each other feedback, by using the Text Feedback game [10]. Formative feedback supports good learning [9] and the aim of this process was to give the students feedback so they could improve on their articles before the final hand-in by the end of the year. However, only 4 groups (out of 14) handed in the first round and 6 groups handed in the second round. When asking the students directly why they didn't hand in for feedback, they answered that they had to work for deadlines in other courses and they considered the last deadline by the end of the autumn semester for the final deadline for this course. The last week before the final deadline to hand in the paper, several students handed in papers to the course responsible, asking for feedback.

The experience from the groups who actually gave each other peer feedback on the articles was that they really appreciated it and it helped them learn. As one student said:

It really took a lot of time to read the other (group's) article and I didn't expect to learn so much from it as I actually did.

3.3 Student evaluation

There were three formal rounds of evaluation of the course; after the spring semester, after the field work period and at the end of the autumn semester. The students were encouraged to give informal feedback during the year to the course responsible.

The evaluation in the spring semester was handed out at the poster session, which was part of the summative assessment for the students, so all students answered the questionnaire.

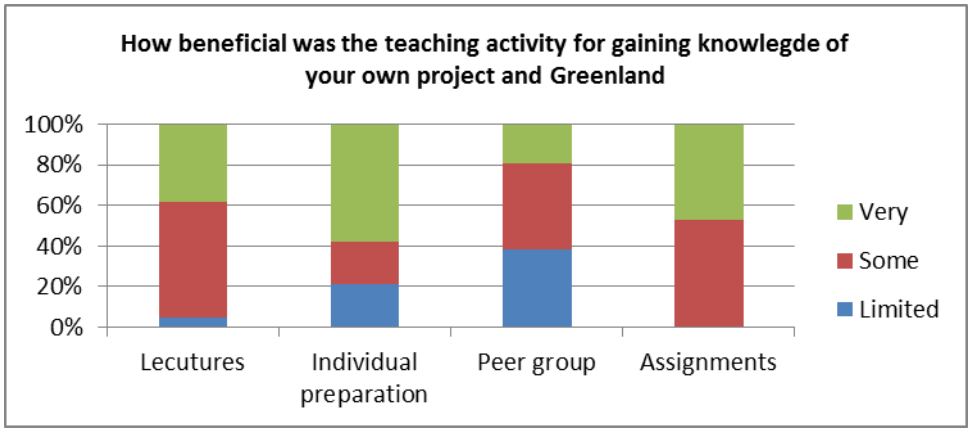

Fig. 1.Students evaluation of teaching methods

It is seen from Figure 1 that the students were the least pleased with the peer group work of the four teaching activities in the spring semester. However, they also answered that they didn't use the peer group in the spring semester as intended. Those students who did also said that they used it more than for the planned activities for the article and poster feedback, such as for social networking (also through Facebook), consulting and feedback on the assignments. Thus, it seems to us that the students who engage in peer group activities gain not only subject wise but also socially, contrarily to what was observed by [8].

The field work period was very successful; the students were working hard and were good in adapting to possible changes that occurred during the field work compared to their original plans. 85 % of the students answered that the field work went mostly according to their original plans. They were most pleased with a trip to the Greenlandic Ice Sheet, their own field work and with the social interactions with the other students during the stay in Greenland.

The standardised Course Experience Questionnaire [11] was handed out to the students after the oral examination. Thus all students following the course answered. The average results from the CEQ are shown in Table 2 and are calculated based on the students' answers (5 Strongly agree – 1 Strongly Disagree) and shows high results from two consecutive years. We generally observe high scores, which indicate a good alignment of the learning objectives, learning activities and assessment. The work load of the course seems to have increased in 2013, which could be due to the new teaching activities (peer-group, article writing) and could also be an indication that the students are not used to these activities from previous courses, which may require higher efforts of the students. However, the slight increase in the motivation results may suggest, that the extra work is worthwhile for the students.

*Table 2. Average r*esults of the CEQ from 2012 and 2013

	2012	**2013**
Good teaching (scale) [GTS]	4.4	4.3
Clear Goals and Standards (scale) [CGS]	3.7	3.7
Appropriate Workload (scale) [AWS]	3.7	3.4
Generic Skills (scale) [GSS]	4.2	4.2
Motivation (Scale) [MS]	4.3	4.5

Further elaboration of the results of the questions for the generic skills is shown in figure 2. Most students taking the course agree that their generic competences are developed. Only 1 or 2 students evaluate some of the generic competences below average and the goals of the course seems fulfilled.

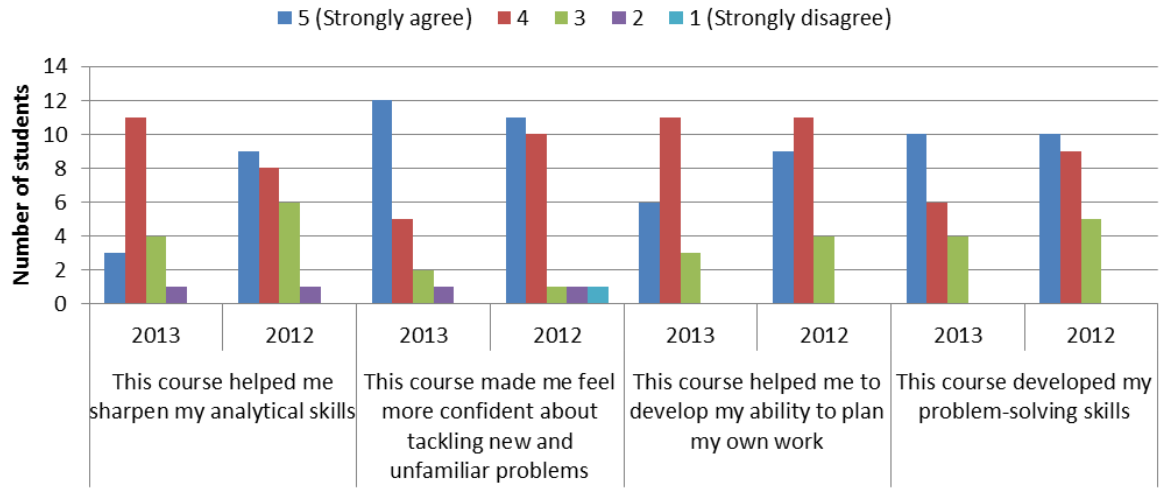

Fig. 2.Elaboration of the GSS results

In the qualitative part of the evaluations, the students generally answered that the field work was beneficial for their learning and were motivated for further exploring their subject in the Arctic. Some of the positive comments concerning the generic competences were:

Once in a lifetime experience! Interesting to do hands on work and practical field work within own field.

Trip to Greenland was very helpful for the report, with lots of practical experience

Making my project happening and writing this article is my biggest academic achievement ever!

The majority of the comments were positive. Negative comments were usually connected to the fact that there are lectures about other subjects than the student's own specific subject, different level in supervision by the subject supervisors and that not all students were willing to use the peer-groups, which is annoying for the students who make an effort.

3.4 Learning outcome and assessment

All students, if they hadn't done it before, learned to plan and accomplish their field work under different societal, cultural and also more challenging conditions than they are used to. Working individually and taking responsibility of own learning and progress in the project are important engineering skills that were developed and at the same time feed the student's intrinsic motivation [9]. Making posters, writing articles and presentations are important communicative tools for engineers. The ability to professionally disseminate relevant engineering subjects in a short and precise way to others in the engineering community is highly important [4]. Time limits for the oral presentations and page limits for the article forced the students to be precise and focussed on getting their message presented, which is a useful competence for their future careers either as engineers working in companies or as researchers.

The student's conceptual understanding of Greenland and the Arctic had really increased during the course and they were all comfortable in answering questions related to their projects at the final oral exam. Most of them were also successful in evaluating their results compared to previous studies and to make final conclusions that can be presented to the stakeholders in Greenland. From the student's deliveries (poster, article, presentation), discussion and feedback during the course, it was clear that not all students were taking responsible for their own project by using the review system, peer groups and subject supervisor as expected. This resulted in not all students being able to relate their own subject completely into the Arctic challenges, which is one of the most important and challenging tasks in this course and this was reflected in the grades. Even though, the grades of this course are generally high, which is most likely a result of the active learning by highly motivated and dedicated students.

4 SUMMARY

In a research based course in Arctic Technology, different teaching activities were used to support learning of both technical and generic competences. The active learning was based around a 3-weeks field work period in Greenland in combination with lectures, assignments, project and peer group work prior to and after the field work. The students represent a heterogeneous group of nationalities, previous experiences and scientific subjects.

It was clearly seen by the learning outcome and assessment that students who used the offered feedback options during the course actively were more successful in achieving both the scientific and generic competences than the students who did not. The students evaluate the course as being highly motivating for further learning and they get confident by successfully having executed a research based project in a new context. The project and field work support the process of developing generic competences and are preparing the students to become professional engineers.

For the future teaching of the course we have some suggestions for improvements:

- Include peer-work as a learning objective and specify rubrics of how to give feedback to make it more worthwhile for the students

- Include the hand-ins of draft articles in the review process as an required element to pass the course, to distribute the work load and secure that all students receive process feedback
- Explicitly tell the students that in the course there is focus on developing generic engineering competences, so they are more aware of this, instead of just focussing on improving their scientific competences

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