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The continuous challenge in teaching Engineering to Students from a Society with no Tradition for Higher Education

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Abstract

The engineering programme in Arctic Technology from the Technical University of Denmark enrolls students from Greenland and Denmark. Since the Greenlandic students underperformed and had a high drop-out rate, several initiatives have been initiated to help the weak Greenlandic students. The results are analysed, and it is clear that even though the initiatives have proved popular, they have not fundamentally solved the problems in giving a higher education to young people from a society with a weak tradition for education.

Keywords: cultural differences, basic sciences, retention, adapted teaching

1 Introduction

Since 2001 the Technical University of Denmark (DTU) has offered a study programme in Arctic Engineering. The programme, which is supported by the government of Greenland, takes place partly in Greenland and partly in Denmark, and enrolls both Greenlandic and Danish students. There are two main objectives for this programme: 1) To educate professionals with a deep understanding of the Arctic and 2) To give the Greenlandic youth a better chance for getting a higher education.

The possibilities for taking a higher education at the University of Greenland 'Ilisimatusarfik' are limited and do not include the Sciences or Technology (www.ilisimatusarfik.gl), and it is a challenge to Greenlandic students to go abroad to study (Johnson, 2009). The Greenlandic students have a low retention rate, when they go to Denmark or elsewhere to take a higher education, even if it requires a higher grade average from high school to get financial support to study outside Greenland than in Greenland. It is difficult to get reliable data, but 192 Greenlandic students started a higher education in Denmark in 2005 & 06 and 86 students graduated 5 years later in 2010 & 11 giving a retention rate of 45%; the corresponding numbers for students studying in Greenland give a retention rate of 51% (www.stat.gl). To help the Greenlandic students to a better start, it was decided to turn the structure of the study programme in Arctic Technology somewhat upside down: To start the studies in Greenland with the arctic specialisation and then continue in Denmark with more standard engineering courses.

On the surface this strategy seemed to work – the retention rate for Arctic Technology was approaching the average at DTU. The teachers felt however that the Greenlandic students had many problems, and a closer examination revealed that the Greenlandic students underperformed and had a much higher dropout rate than the Danish students in the programme. Several reasons can be given for this (Kahlig & Banerjee, 2007), and a number of initiatives have been taken to help the Greenlandic students. In many ways they have been successful, but they have not fundamentally solved the problems involved in giving a higher education to students from a newly developed society with a weak tradition for education.

In this paper the Greenlandic students' background is first discussed, and a brief summary of the structure of the engineering programme in Arctic Technology is given. Then some initiatives to increase the number of Greenlandic graduates are described followed by some statistical data, and finally the results are discussed and some conclusions drawn.

2 The Greenlandic student

The small Arctic Greenlandic society, which, with a population of only approximately 56.000, is part of the Danish Kingdom, is now a modern society with Self Rule, but only half a century ago it was primarily a fisher and hunter society governed as a colony by a Danish elite. But in many ways it is different from other former colonies. The living standard in the urban areas, where most people live, is relatively high, with high salaries and high costs of living. Approximately half the national budget is supplied from Denmark. The population is a mixture of the indigenous Greenlandic

Inuit population and Europeans (mostly Danish) with no clear division between the groups. But in some ways Greenland also have many societal problems like other new democracies.

It is difficult to run the primary and secondary school systems in Greenland due to the structural and logistic problems, when very few people are spread over an enormous area with very limited infrastructure. From high school or even earlier students have to live on boarding schools seeing their family only a few times a year – and family means a lot to Greenlandic people.

There is sufficient money to support an efficient educational system; EU is earmarking a large part of the money paid for fishing rights in Greenlandic Waters to education – the problem is to get it to work. The first Greenlandic higher educational institution was a school to educate teachers (and local priests). Still there are not enough practicing Greenlandic teachers to give Greenlandic children a good primary school experience. The Greenlandic high schools, which until a year ago were a copy of the Danish school system, are almost exclusively taught by Danish teachers – and even if Danish is taught to Greenlandic children from a young age, the native non Indo-European Inuit language is so far from Danish that many students master Danish at a rather rudimentary level. And the cultural background embedded in the Greenlandic language makes it very difficult to comprehend topics at an abstract level.

It is very difficult to learn at university what you should have learned in high school, and it is very difficult to learn in high school what you should have learned in primary school – and even if you get good high school grades, you may have big problems with basic knowledge not tested in high school.

On the surface Greenlandic student acts very much like European students, but below the surface the cultural roots sinks deep resulting in a very unpredictable behaviour from a western cultural viewpoint. Up to 50 % drops out of high school, and those graduating have often unsuitable study habits for a higher education. The students going to university are the good students, which have never experienced serious consequences of erratic behaviour and not doing their school work, so when they face this in higher education, it comes as a surprise to them, and for many it takes (too) long to adopt to this situation.

3 The Engineering programme in Arctic Technology

The professional bachelor programme in Arctic Engineering is unique in several ways: The students start their education in the small city of Sisimiut in Greenland with a population of approximately 3000 and finish it at the large DTU Lyngby campus in Copenhagen, the students are a mixture of Greenlanders and Danes, and the teaching structure of the first three semesters in Greenland is organized quite different from the norm at DTU in Denmark. Almost all teachers live in Denmark and travel to Greenland to teach full time for one to three weeks, and then a new teacher arrives to teach new topics. This means that the students at any time only have one course, which is finished and evaluated before the next start (in contrast to the situation at DTU in Denmark, where they can have up to six courses in parallel, and most are evaluated at the end of the semester). As a consequence of this the students tend to spend much time in class.

4 Initiatives to increase the number of Greenlandic graduates

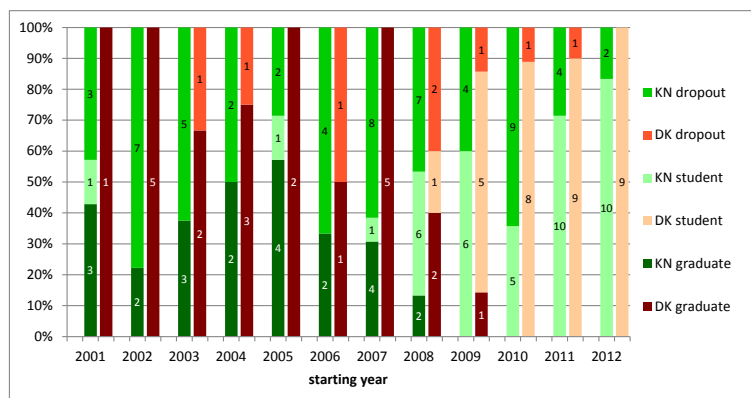


Figure 1: Statistics for Greenlandic (KN – the green bars at the left) and Danish (DK – the red bars at the right) students at Arctic Technology. Dark colours at the bottom indicate graduated engineers. Light colours in the middle indicate students still active. Medium colours at the top indicate students that have dropped out.

4.1 The problems

After the first five years of the programme it was clear that something had to be done, if the programme was not to be closed down. Two problems had to be attended:

- 1) The enrolment in the programme was insufficient; it had dropped to 8-9 students each year of which 5-7 were from Greenland.
- 2) Too many Greenlandic students dropped out as indicated in Figure 1, and many of those who remained underperformed. The accumulated retention rate for students starting 2001-2007 is 43% for Greenlandic students and 86% for Danish.

4.2 The remedies

4.2.1 The new curriculum

In 2007 it was decided to change the curriculum structure from a theoretical to a practical active-learning approach. The curriculum was reorganised from single-subject courses into large interdisciplinary courses with intercultural group work based on authentic local cases – called composite courses (Christensen, 2008; Ingeman-Nielsen & Christensen, 2011). This change can be argued based on general learning theory (Brandsford et al., 2000), but it was also an attempt to introduce a teaching philosophy more aligned with the Greenlandic students' cultural background (Hoffmann et al., 2011).

The active learning was enforced via the overall structure, which assured the active participation of the students. The teachers were not required to use any specific teaching methodology, since different methods may work in different situations, Brandsford et al. (2000 p. 22) writes "Asking which teaching technique is best is analogous to asking which tool is best - a hammer, a screwdriver, a knife, or pliers. ... There is no universal best teaching practice." Per Fibæk Laursen (2004) calls this the principle of *non-specificity* in teaching. It is not the methods or techniques that are of critical importance for student learning, but the way you use them. And teachers going to Greenland to teach are very dedicated teachers, so they develop their own best practice.

The change was a success. The enrolment increased dramatic; it tripled from 2007 to 2010. The students were happy with the practical approach in the composite courses. And the teachers were happy because the students showed up to classes and participated actively in the activities.

This success however also introduced some problems, since more Greenlandic students with weak preconditions for a university study were enrolled.

4.2.2 The retention project

Together with the new curriculum, a project (Fastholdelse gennem Øget StudieKompetence – Retention through enhanced Study Competence) to limit the dropout rate funded by the Greenland Government (as part of an initiative to increase retention in the Greenlandic educational system in general) was started up. The project included a theoretical part to inquire into why the students dropped out of the programme and a practical part including a coach to support the students in Greenland.

The project was a success in creating a class in Greenland that was socially strong and seemed well prepared for the study in Denmark. Much to the despair of the teachers and the coach, however, the class completely disintegrated when transferred to Denmark, with an average pass in the first semester in Denmark of 1.3 courses out of 5 for the Greenlandic students (the Danish Arctic Technology students in the class passed in average 4.8 courses).

It is an enormous challenge to the Greenlandic students to adapt at the same time both to the living in a big city and the independent study at a big university (there are more students at the DTU Lyngby campus than there are people in Sisimiut – and the area of the Lyngby campus is comparable to the area of Sisimiut).

Something had to be done, and it was decided to implement two changes in the strategy:

- 1) The focus should still be on giving the Greenlandic students a good start. But since the study includes a transfer to Denmark, it was equally important to prepare the students for the much different life at the big campus in Lyngby, where much more independent work is required.

Studying in the small strongly supported environment in Sisimiut is not the best preparation for the Danish campus. Therefore the close support of the students should decrease at the second semester and stop at the third semester, so those not capable of studying on their own, would not be transferred to Denmark – almost inverting the original

strategy of trying to keep as many students as possible in the programme. It is better for all that a student stops in Sisimiut, than s/he is transferred to Denmark and is faced with a fiasco there.

2) The focus of the coaching was shifted to Lyngby, so the Greenlandic students have access to a coach especially at the first semester in Lyngby. And the Arctic Technology Centre in Lyngby set up an incoming programme to welcome the arctic students, right from when they landed in the airport.

4.2.3 Language support

Most Greenlandic students without at least one Danish speaking parent or without spending 10th grade at a Danish boarding school have severe problems with the Danish language – how much this influence the student's performance and what to do about it, is a continuing topic for debate in the teacher group.

Several approaches to help improve language skills have been tried out. The main problem is that only few students are willing to admit that they have a problem, so volunteer classes in Danish have not been an overwhelming success. Another approach has been to require students handing in written assignment in bad language to rewrite the assignment with the help of a Danish language teacher – the difficulty with this approach is to get the course teacher to focus on the language and not only on the content.

The bad news is that all students, who have had language support since 2007, eventually all have dropped out.

4.2.4 Individual Math-Physics remedy plans

At the Arctic Engineering Students Challenge Workshop in Sisimiut 2010 (Boffil et al., 2010) it was suggested to make individual remedy plans for each student – and since Math and Physics are the big challenges for many of the Greenlandic students due to missing competences from primary and secondary school, it was decided to focus on these topics.

The first course in Math and Physics is given at the second semester, but already at the beginning of the first semester, the students were given an entry test in Math and Physics. After the test individual remedy plans were set up for each student specifying weekly assignments in different topics, which the student should hand in during the first semester, and a teaching assistant was assigned to help them and give feedback.

The students like this chance to get a good start in the Math and Physics course; more students than have to attend the teaching assistant's classes. And the teacher saves time in the course, since you don't feel obliged to do any repetition of high school topics.

5 Statistical data

5.1 The years 2007-2010

The average grade for the first 3 semesters for students enrolled 2007-2010 is presented for respectively 39 Greenlandic (KN) and 24 Danish (DK) students in Figure 2.

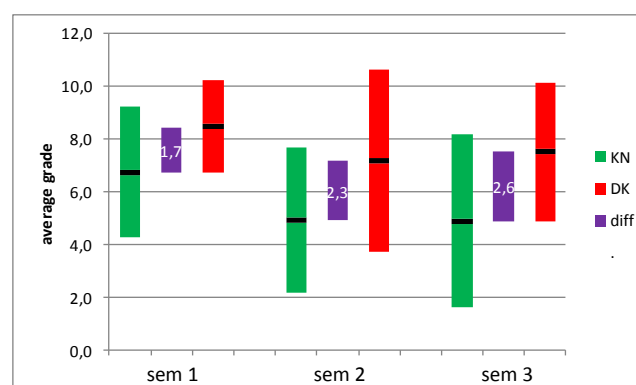


Figure 2: Average grades with standard deviation for courses at the first 3 semesters respectively of Arctic Technology for Greenlandic (KN) and Danish (DK) students starting 2007-2010. The small bars with numbers indicate the difference between average grades for Greenlandic and Danish students.

The Greenlandic students have lower average grades. Unfortunately the difference between Greenlandic and Danish students grows from the first to the third semester; the second semester has the more mathematical challenging courses, so a drop for both groups are not surprising, but where Danish students recover a little at the third semester, the average for Greenlandic students continues to decrease. It could have been hoped that the difference between different student groups would level out.

5.2 Students starting year 2010

23 students started September 2010; 14 students from Greenland and 9 students from Denmark. 5 Greenlandic students dropped out during 1st and 2nd semester.

In addition to passing a high school exam, the students must pass the following courses in order to enrol in the Engineering Programme in Arctic Technology: Mathematics A (high level), Physics B (medium level) and Chemistry C (low level). The Danish grading scale goes from 12 (A) to –3 (F) with 02 (E) as the minimum grade to pass and 7 (C) as the average grade.

In Figure 3 the average grades for students for the first 3 semesters are plotted as function of their M4P2F1 high school grade, which is calculated with a weight of 4/7 for Mathematics, 2/7 for Physics and 1/7 for Chemistry.

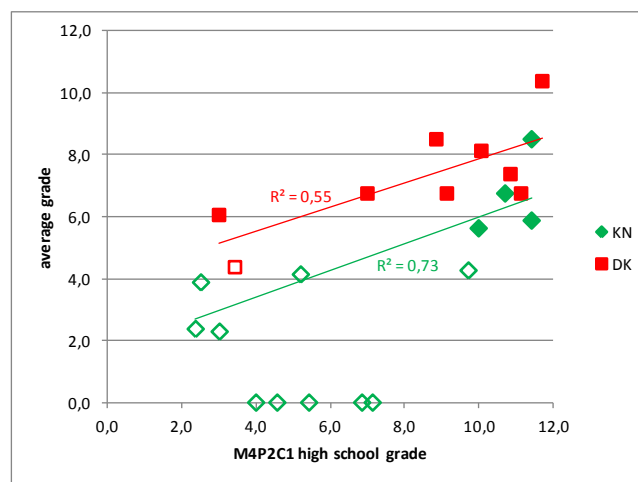


Figure 3: Average grades for the first 1½ year of Arctic Technology for Greenlandic (KN) and Danish (DK) students starting 2010 as function of their M4P2C1 high school grade. Students dropped out have been given the average grade 0. Closed symbols indicate students who passed all courses.

There is a good positive correlation between the average grade the first 3 semesters and the M4P2C1 grade for each student group (student dropped out not included), but the linear regression line is approximately 2 points lower for Greenlandic students than for Danish.

No Greenlandic student with a M4P2C1 high school grade below 10 (B) has passed all courses at the first three semesters in Greenland, which is required for being transferred to Denmark for continued studies.

3 of the 5 Greenlandic students who did not pass all courses have later dropped out, and the two remaining had 1 year later not yet been transferred to Denmark.

5.3 The course Mathematics in Physics

The integrated course Mathematics in Physics is the students' first course in math and physics. The course has a total length of 6 weeks full time study.

5.3.1 Entry test

The students score in the entry test is given in Figure 4 versus the MathPhys high school grade based on 75 % Mathematic grade and 25 % Physics grade, which are approximately the weights of the two subjects in the entry test and in the Mathematics in Physics course.

There is a relatively good positive correlation between the students' entry test score and their MathPhys grade for the Greenlandic, whereas there is a much higher spread for the Danish students.

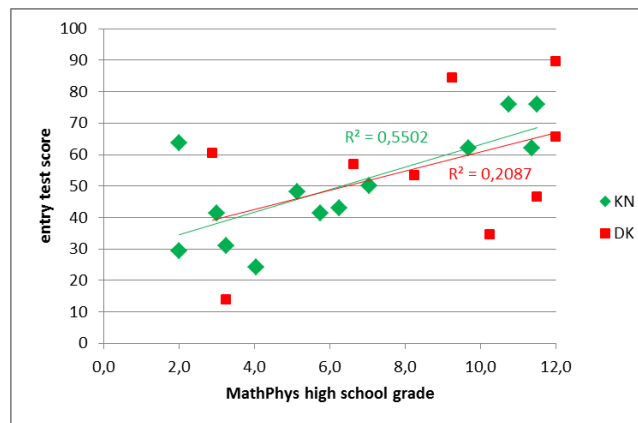


Figure 4: Entry test score as function of the MathPhys high school grade

After the remedy programme the test was given again. The Danish students participated in average more in the remedy programme than the Greenlandic students, but the Greenlandic students increased their average test score much more than the Danish. The test was given once more after the course Mathematics in Physics. The average score in the different topics are shown in Figure 5 for the Greenlandic and Danish students still in the programme at the end of the course.

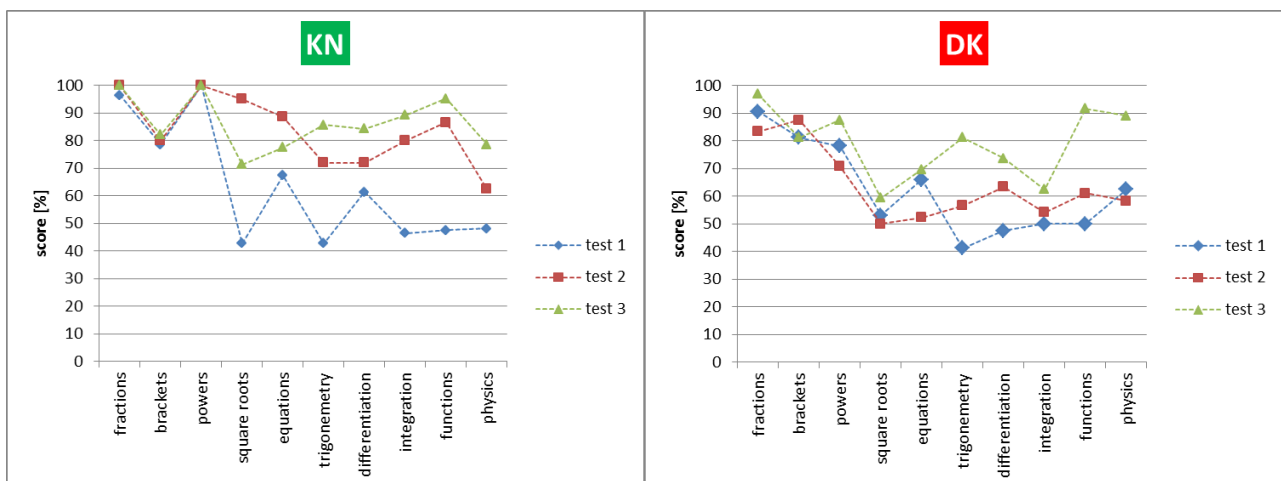


Figure 5: Average entry test scores for the different topics in the entry test for Greenlandic (KN) and Danish (DK) students for the three times the test was given. Test 1 was given in the beginning of the 1st semester, test 2 at the end of the semester after the remedy programme and test 3 was given at the end of the Mathematics in Physics course at the 2nd semester.

There is a very large spread on student performance in the different topics. The Greenlandic students apparently have had a good drill in fractions and powers, but had troubles with the fundamental roles of brackets in mathematical expressions – and this did not improve. Both groups have significant difficulties with square roots, and there is no significant improvement; the Greenlandic students scored high on square roots in test two but did not in test three. The Danish students had no improvements in the first 5 very basic topics – what you don't have learned in primary and secondary school is very hard to come after in further education. The improvements in the less basic topics are more clear – especially for the Greenlandic students.

5.3.2 Study habits

The students were asked to register their study activity for each half hour 24 hours a day 7 days a week during the Mathematics in Physics course.

The students average study load was 33 ± 9 hours/week. This is comparable, to what has been obtained in previous investigations at DTU (Christensen et al., 2009), but less, than have been reported elsewhere (Christensen, Gras-Martí & Ávila Bernal, 2012). Compared to an expected DTU weekly study load of min. 40 hours the students in average studied at 82 % of the norm with a few over the expectancy. The average distribution between different activities (attend-

ing class, doing assignments at home (there was an assignment almost every day) and reading theory) is given Figure 6.

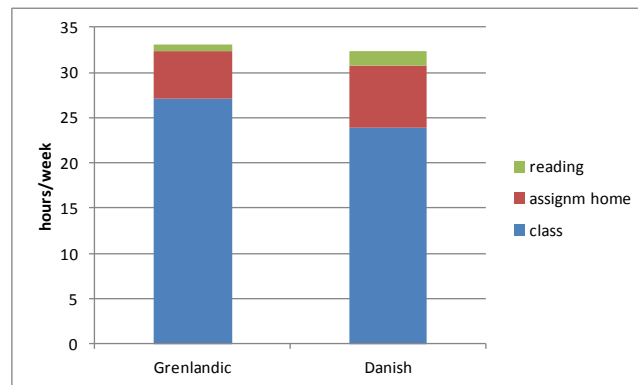


Figure 6: Total study time and distribution of time spent on different study activities for Greenlandic and Danish students

There is not any significant difference in total study load between Greenlandic and Danish students (average 33.1 compared to average 32.4), but there is a clear difference in the way they study. Greenlandic students spend in average more time in class and spend in average only half as much time reading as their Danish colleagues – but there is a big spread; the min and max values are almost equal for the two groups.

There was no difference in the average number of assignments handed in by the two groups.

5.3.3 Exam

The exam in the course consists of two parts: A 1-hour conceptual test and a 1½-day assignment, and both parts must be passed in order to pass the exam. 6 students failed the exam (3 Greenlandic and 3 Danish).

There is a good positive correlation between the average exam score and the entry level defined as the average between the MathPhys high school grade and entry test 1 score as shown for the two groups in Figure 7 – the good students at the beginning is still the good students at the end of the course.

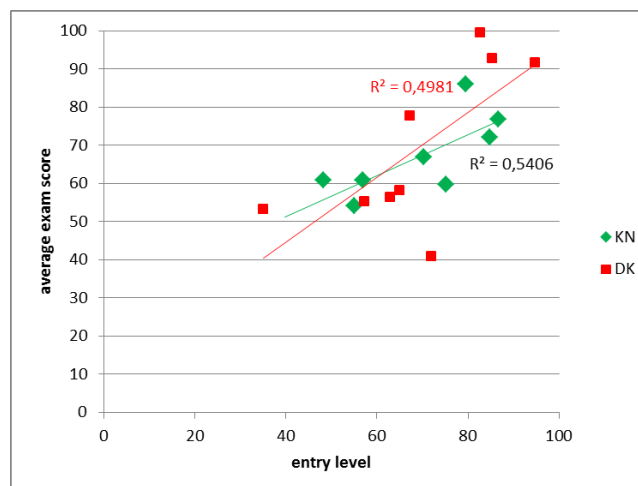


Figure 7: Average exam score in the course Math in Physics as function of entry level for Greenlandic (KN) and Danish (DK) students

There was no overall correlation between average exam score and neither total study load or study strategy, but the score in the 1½-day assignment had a good correlation with study load for the Greenlandic students as shown in Figure 8, whereas there was no correlation for the Danish students.

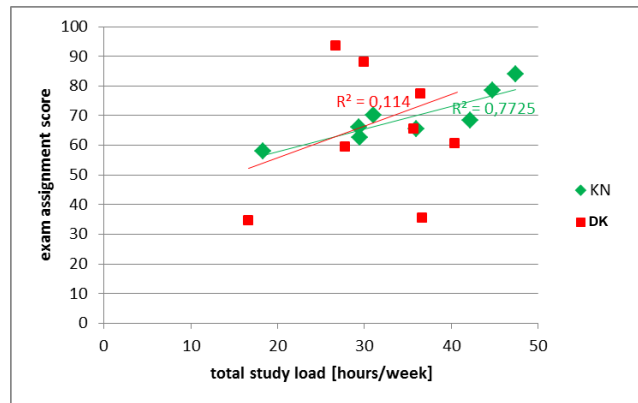


Figure 8: Score in the 1½-day exam assignment versus total study load for Greenlandic (KN) and Danish (DK) students

6 Discussion and conclusions

Greenlandic students underperform, and relatively more Greenlandic than Danish students drop out of the engineering education in Arctic Technology. One obvious reason for this is that in average the Greenlandic students come with lower high school grades (M4P2K1 = 7.4) than the Danish Students (M4P2k1=8.4; mostly due to higher grades in Physics).

But this cannot be the whole explanation. When comparing the Greenlandic and Danish students starting in the years 2007 to 2010 (Figure 2) the difference between Greenlandic and Danish students grow during the three semesters while still in Greenland indicating that Danish students seem to adopt better to university studies than Greenlandic. One reason for this could be that the students are required to be more independent at the third semester and Greenlandic students don't handle this well.

And as seen from Figure 3 a Greenlandic student starting in 2010 with the same M4P2K1 high school grade as a Danish student is likely to get a two point lower grade in average over the three first semesters – even when those dropped out are excluded. This could be that Greenlandic high school grades are inflated, but they use the same exam questions and external examiners as in Denmark, and when tested in Math and Physics at the start of the programme, there was no difference between Greenlandic and Danish students (both groups scored 56% in average). Another explanation for this could be that often Greenlandic students also have a language problem, and a language problem becomes very serious at university level, when you have to read and understand texts and not just follow procedures.

The high school grades seem to be valid (Figure 4) and these grades seem to have more influence on grades than total study load or study habits. It is possible that a high study load can improve a student's skills in problem solving for students depending more on following learned procedures than independent problem solving as indicated for Greenlandic students in Figure 6. But study habits seem not correlated with conceptual understanding.

The welcome programme in Lyngby has not been a full success, because the Greenlandic students have not fully used the offerings from the coach. The Greenlandic students apparently don't see a need for special help before it is more or less too late. Workshops on how to study efficiently have been attended mostly by Danish students or been cancelled due to too few participants.

6.1 Conclusions

The average retention rate of 43% for Greenlandic students of the first 8 classes of Arctic Technology is comparable to that for Greenlandic students starting their university study in Denmark. However, a higher high school grade average is required to get Greenlandic financial support to study outside Greenland than to study Arctic Technology, which in this respect is considered a Greenlandic education, so students with lower grades are admitted, even though they have to do most of their study outside Greenland.

Many Greenlandic students enrol in the Arctic Technology programme because they cannot get the education they really want, or because they don't know what they want, and then they try out Arctic Technology because it is right there in Greenland. This does not create the highest motivation, and will lead to somebody that could graduate will leave for other studies. And because the study starts in Greenland, many excellent students choose another study, because they want to try the world outside the small Greenlandic society.

With the present intake of students, where many have low motivation and very low grades in Math and Physics from high school, it does not seem likely – and maybe not even desirable – to increase the retention rate for Greenlandic students significantly. It is not possible in a demanding and intensive engineering programme to help students with missing basic competences in basic sciences or language from primary and secondary school to catch up on 10 years of neglect – this deficit cannot be mended by classes and tutoring offered in addition to the normal courses.

If it will not be possible to increase the admission requirements to language skills and basic competences in the sciences, it is important to stop the students without any chance for graduation during the first three semesters in Sisimiut before they are transferred to Denmark. After the introduction of the welcome programme in Lyngby and more focus on stopping the very weak students in Sisimiut a beginning decrease in drop out in Lyngby can be expected.

Focus in the future should therefore be on helping the clever but underperforming middle group of Greenlandic students to obtain good study habits, so they can overcome the problems with their cultural-related weak preconditions for a university study. And the welcoming programme in Denmark should be intensified. If the Greenlandic students don't come to the coach, the coach must come to the students, if a further decrease in drop-out rate in Denmark should be obtained.

But let's end on a positive note: More and more Greenlanders graduate as Arctic Engineers every year, and they go back to Greenland to work.

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