A MANIFOLD APPROACH TO INCREASE EXAMINATION RATE DURING FRESHMAN YEAR

Kjell Jeppson[1], Marie Bernelo, Ann-Marie Danielsson-Alatalo, Leif Lundkvist, Per Lundgren, and Lena Peterson[2]

Abstract *Results from an extensive study of why a substantial number of students at the Electrical Engineering and Computer Engineering programs at Chalmers University of Technology choose to interrupt their studies during the first two years will be presented. Efforts from our side to lower the attrition rate and improve student success will also be presented. Such efforts include Introductory Calculus courses, mentor programs and supplemental instruction, peer learning groups, "second chance" repetition courses, and introductory project courses.*

The presentation will point out some important reasons why students choose to leave the EE and CE programs to which they have been accepted. We have also looked for early warning signs. One important observation is that of those students who fail in the first calculus examination as many as 40% will drop out during the first three terms. On the other hand, of the students who pass the first calculus examination only 4% drop out. So, warning signals are visible already at mid-term after 8 weeks. Special efforts to improve student success and avoid failure in the first math examination will be presented. Those students who fail in the first calculus examination (despite our efforts to prevent this from happening) was offered a "second chance repetition course in mathematics" and results from this effort will be reported.

Index Terms ¾ Freshman year, introductory mathematics, examination rate, attrition rate, peer learning groups.

INTRODUCTION

In this paper we will describe a number of efforts from the School of Electrical and Computer Engineering at Chalmers University of Technology to improve its support to the freshman students in order to make their studies in our program successful. There are already some early signs that indicate that these efforts are improving the examination rate and hopefully they will bring down the attrition rate as well. Our efforts have been concentrated to the first term, and in particular to the first introductory month. The main purpose of this effort is to bridge the gap between the university and the secondary school. To support the maturity process when high school kids become university students.

Each year about 210 students are accepted to the Electrical Engineering (EE) program by the school and 160 students are accepted to the Computer Engineering (CE) program. It is important to know that the selection procedure is not handled by the university itself, but is organised nationally by the Government office "Verket för högskoleservice". The university has no influence on which students are accepted to its programs. About 4/7 of the students are accepted based on their grades from secondary school (high school), 2/7 are accepted based on their results in the national university test ("högskoleprovet"), and about 1/7 have other backgrounds (including foreign schools). The number of first-hand applicants is about two students per seat available. However, the rate has decreased during recent years as indicated in Fig. 1. This can partly be explained by the fact that the number of university seats, as well as the number of available programs, has increased in recent years.

Error! Not a valid link.FIGURE 1.
THE NUMBER OF AVAILABLE EE SEATS AT CHALMERS (LEFT AXIS) AND THE NUMBER OF FIRST-HAND APPLICANTS PER SEAT (RIGHT AXIS).

The strong increase in the number of seats available at the universities, particularly in the field of technical educations, is largely a result of the expansion of the local universities that have been established during the last decade. Unfortunately, this increase has not been accompanied by any increase in the number of secondary school students choosing the natural science programs that are preparatory for university studies in engineering. This has led to an increasing number of freshman students lacking the necessary prerequisites and having poor skills in mathematics. The group of students that are accepted by the universities but really lack motivation for university studies has also increased in number, with an increasing attrition rate as a result. Also, to many students it appears to come as a surprise that successful university studies require many hours of hard work.

For many years, the study counsellors at the EE program have invested a large amount of time and effort to inform freshman students about how to study at the university and about the learning process. The importance of taking their studies seriously from day one has been pointed out extensively. The message from the school has been very clear: invest seriously in your studies and be low on leisure time activities until you know how much work is required to pass the (midterm) examination.

On the other hand there are many things that are new to the students at the start of the first term: new school, new friends, etc. For many students it is also a new city, and

[1] Kjell Jeppson, Chalmers University of Technology, School of Electrical and Computer Engineering, FTE/MC2, Göteborg, Sweden, kjellj@ic.chalmers.se
[2] All authors are with Chalmers University of Technology, School of Electrical and Computer Engineering, Göteborg, Sweden,

many of them will be living by themselves for the first time. The students union offers an extensive social program during the introductory weeks to make the students feel welcome to Chalmers, the school where they are going to spend the next 4-5 years of their lives. Although being very effective both in the short and the long term perspective such social programs offer many "temptations" in form of parties, pubs, outdoor gatherings, student competitions, etc which might steal time from the studies if you participate in all or too many of these activities. The right balance is very important, the social activities are necessary but we must always remember that when it comes down to business students are there for the studies.

Clearly, the university wants as many students as possible to pass the introductory math examination. This introductory course examination comes very early, and arranged after the 2-3 week introductory course that is common for most of the engineering programs at Chalmers. Our experience says that most students who pass the first examination are successful in the coming examinations as well. There is an upward spiral effect. On the other hand, of the students failing the first examination 2 out 5 will leave the program within the first three terms. If you find yourself trapped in the downwards spiral, the trend might be difficult to break even if the EE program for many years has had an extensive program trying to do exactly this. Weak students who fail the initial examinations are called for discussions with their study counsellor who offers continuous support in how to get their studies back on track.

Even though we believed that we had a strong program we felt a need for further improvements as the attrition rate started to increase in 1996 and 1997. That fact that this increase coincided with a major reform of the EE curriculum made us even more alert and worried, even if we were convinced that we offered a much better freshman year in the new curriculum.

In the new curriculum we had already started a project course which was offered to all EE students already during the first term. Here, we collected the English course and the Computer introduction course in one hat together with a project that was performed in groups of eight students. Each project group was assigned a supervisor from the research groups of the different departments of the school. These project groups offered the students a chance to be seen, and to be identified as individuals. In the group they got to know each other and they got the chance early on to meet a faculty member who could serve as a mentor to the group. This project has been named FirstQuest and is reported in a later section of this paper.

As we felt a need for a more methodical way to proceed we started a number of activities and pilot studies, the results of which was carefully monitored. One of the first studies was the drop-out study in which the results of all 1339 students who were accepted to the EE and CE programs during 1996-1999 have been mapped. Of these students no less than 202 (15%) decided, for different reasons, to leave the program during the first two years. In this investigation we tried to find their reasons for leaving the EE/CE programs, when they decided to leave and what they did instead. The results are reported in the next section.

Other efforts included massive recruiting campaigns for which we produced new brochures, arranged open-house activities for students from the surrounding secondary schools, arranged short one-day electronics courses for secondary school women students, sent second-year students as alumni to their old home-town school to inform about university studies in general - and EE and CE studies at Chalmers in particular, etc. All these efforts have been developed in co-operation with the EE/CE student unions through different co-operative groups. Particular emphasis has been put on being very clear and explicit about the necessary prerequisites for successful university studies, not just producing flashy brochures.

Large efforts were focused on co-operation with the student union in developing a joint welcoming program for the first month when the freshman students arrive. Here we have been working hard trying to establish a paradigm shift, a shift from just having fun to having fun while you study. Through short-courses sophomore students volunteering as mentors have been made aware of their responsibilities as role models. We believe that these efforts have been successful, even if we are fully aware that a paradigm shifts take time to accomplish.

Next, a mentor math program was started. Already in the introductory calculus course one hour was scheduled and set aside each day for the students to reflect over the topics of today´s lectures. Questions like "What was it he [the lecturer] said this morning about hyperbolic functions? I did not get it, did you?" could be discussed in peer groups of eight students under the supervision of a sophomore mentor.

In the Calculus A course the mentor concept was further refined and arranged to follow the theme of supplemental instructions [1]. This was done in co-operation with Lund University and and the University of Missouri-Kansas City.

Last year, the introductory math course was extended from two to three weeks to give more room for practise. At the same time Calculus A was shortened accordingly and some of the material was moved from the fall term to the spring term courses. The results of these efforts are reported in the Results section.

Finally we have complemented the efforts listed above with an Early warning systems program [2]. In this program, we try to map the background and individual needs of the students through an extensive questionnaire that the students are requested to fill in during their first day at Chalmers.

DROP-OUT INTERVIEWS

The reasons for students to interrupt their studies and drop out from the EE and CE programs have been investigated in

an extensive study. During the four academic years from 1996/97 to 1999/00, 1339 students were accepted to the CE and EE programs at Chalmers University of Technology. By March 1, 2000 202 of these students (36 women and 166 men) had interrupted their studies and left. 123 (61%) did so during their freshman year, while 79 did so during their sophomore year. An interesting difference between the two programs was noted: of the students terminating their studies 71,5% did so during the freshman year in the CE program compared to only 56% in the EE programs. See Fig. 2.

Error! Not a valid link. FIGURE 2.
THE DISTRIBUTION OF DROP-OUT STUDENTS PER TERM AT THE EE AND CE PROGRAMS DURING 1996/97-1999/00.

The drop-out students were interviewed and their reasons for dropping-out were investigated. The most common reason for terminating their studies that was given by the students was that the program did not meet their expectations ("valt fel"). Some of the students in this group left because they were transferred to their first-hand choice, while others found out that they did not have the proper prerequisite knowledge or that the educational program did not have the focus they had expected. Lack of prerequisite knowledge was again the second most common reason for dropping out. Thereafter follows social reasons, lack of motivation, transfer to other masters programs, etc.

The CE program attracts slightly more women than the EE program. For EE 119 students are women (13,9% out of the 856 EE students), of these 22 have left (which corresponds to 18,5% of the women students). For CE 73 of the students are women (which corresponds to 15,1% of all 483 CE students), of these 14 have left the program (which corresponds to 19,2% of the women students).

As already indicated in Fig. 2 interrupts come earlier at the CE program than at the EE program. The reasons for this are not fully clear. One reason might be that in the CE program you take both Calculus and Programming courses during the first year while in the EE program you do not meet the difficulties of programming until the second year. Another reason could be that it is not fully clear to all students what a CE program is (as compared to Computer Science programs). Therefore more CE students might find that the CE program did not meet their expectations. Possibly, this is supported by the fact that more students (33%) leave the CE program because of lack of prerequisite skills than leave the EE program (20%).

Of the 202 leaving their programs we know that 84 have transferred to other programs. Of these 32 transfer to a different engineering program at Chalmers while 7 go to a similar program at another university. 45 choose to transfer to a non-engineering education.

The most interesting part of the study is to compare the examination results from the introductory math tests with the drop-out statistics. As shown in Fig. 3, 40% of the students who fail in examination will drop out (corresponding to 45 students out of the 114 who failed this test). For the midterm Calculus A examination the results are even more informative. In this examination 279 students have failed during the four years. Forty-five percent, or 112, of these students drop out during the first two years. On the other hand, if you pass the Calculus A examination there is only a four per cent chance that you will drop out during the first two years. This is a true upward spiral effect.

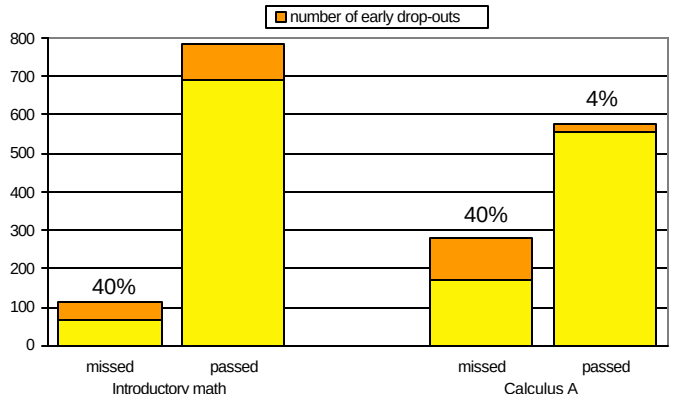

FIGURE 3.
RELATION BETWEEN EXAMINATION RESULTS AND DROP-OUT STATISTICS.

INTERVIEWS AND FOLLOW-UP OF THE 38

During 1999/00 38 students failed both the Calculus A and the Calculus B examinations. Given the results in the drop-out study above, these 38 students were called for an interview by the study counsellors. 35 students came to these interviews. The interviews gave the following results:

- Age: 19-21 yrs: 22, 22+ yrs: 12.
- Living: with parents: 11, dormitory: 7.
- Background: N/V: 26, komvux: 4, foreign students: 2.
- First-hand choice: EE 23, CE 4, other 7.
- Motivation: very good 17, good 15, low 2.
- Comfort: very good 9, good 16, OK 10.
- Math. Prerequisites: good 18, poor 16.
- Calculus A. About content: difficult 16, OK 17. About lecture pace: too high 22, OK 10.

All 38 students had attended the lectures and participated in the group exercises. Nevertheless, they failed both examinations. To help up the situation 26 students said they wanted supportive teaching, while 11 wanted more help from a mentor or more hours for learning in peer groups. 21 wanted more hours set aside for problem solving in class.

No definite conclusions could be drawn from the interviews. However, in order to break the downward spiral these thirty-eight students were given an offer to participate in the Math A/B project that is described in the next section.

PROJECT MATH A/B

The Math A/B-project was organised in the spring term 2000. Usually, the Calculus A and B courses are only offered during the autumn term. However, during 99/00

these courses were repeated during the spring. Instead of letting students, who have failed both Calculus A and Calculus B, continue to Calculus C and D, with a high risk of failing again, they were offered a supportive repetition math program. The idea was to let the students repeat Calculus A and B during the third period (first half of spring term), instead of letting them study Calculus C. This course was instead offered in the fourth period, in parallel to the ordinary Calculus D course. Finally, by offering Calculus D as a summer course it would be possible for the students to be back on track by the start of the next autumn term.

The examination results for the 38 students participating in this project are shown in Fig. 4.

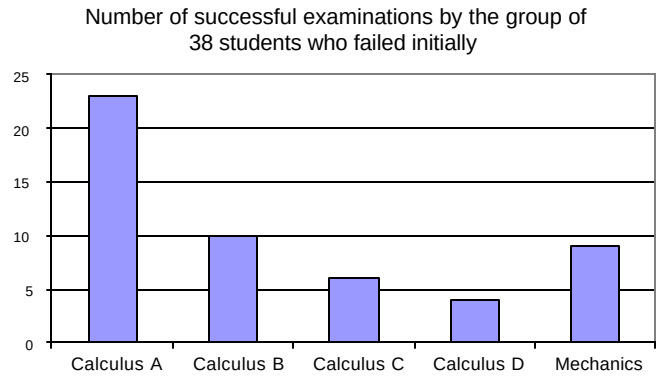

FIGURE 4.

The project started well as twenty-three of the thirty-eight students passed the Calculus A examination after three weeks of repetition classes. However, already in Calculus B problems started to rise as only ten of the students passed this test. Finally, the Calculus D summer course examination was passed by only four students (while ten failed).

The total number of credit units collected by the group of thirty-eight students (at three different occasions) is shown in Fig. 5. The diagram shows that three students perform extremely well and have not missed many credit units neither at the 40-unit level nor when passing the 60-unit level. Another three students are performing well but are lagging behind one term (20 units). Among the five students at the 30-unit level only one has produced ten units (out of forty) during the last academic year. The others that are one year or more behind are not very active (or successful). At most they have passed one or two examinations. Their chances of ever getting a degree must be considered very low at this time.

Error! Not a valid link.FIGURE 5.
THE NUMBER OF CREDIT UNITS COLLECTED BY THE 38 STUDENTS IN THE GROUP.

We have done a similar follow-up on the group of students that was accepted in the autumn of 1995 and who showed similar problems at the start of their studies. On July 1, 2000 their credit unit status was investigated and the results are shown in Fig. 6.

Error! Not a valid link.FIGURE 6.

Only one student had received his degree within five years from the start. In an earlier interview, he stated poor prerequisite knowledge as the reason for his poor performance during the first term. Actually, half of the students in this H-95 group claimed poor or lacking prerequisite knowledge as the reason for their poor results during the first term (sometimes in combination with other reasons – like not taking studies seriously enough from the start. It is evident that the contact with the study counsellors was important and that the support they got in planning their studies was of vital importance for breaking the negative trend.

THE FIRST QUEST PROJECT

The first few months at the university constitute a critical transition stage for many students. Many issues can be said to play a role when the students either consolidate their choice of education or choose to abandon their studies after just a few steps along the road. Whether the individual choice is for better or for worse is of course a complicated matter that depends on which viewpoint you take, and what the alternative route turns out to result in. It is nevertheless our conviction that a decision based on adequate information is better than one taken on a whim. The introductory weeks at Chalmers constitute a potentially very intense situation, where much of the student's attention will have to be focussed on "here and now" issues. A decision to leave that is based on a simple extrapolation of this maybe not so representative situation would not be a well informed one.

The introductory course in electrical engineering has a particular constituent the purpose of which is to give a complementary perspective on the subject and studies ahead. This part of the introduction is called "FirstQuest" and is conducted in groups of less than eight students and one (or two) supervisors from the school of electrical and computer engineering. Each group has a scheduled two-hour meeting with the supervisor each week, and their work within the frames of "FirstQuest" are to be reported orally and individually in English at the end of the first semester (before Christmas holidays) as well as in a written report which is composed by the group. These reports constitute the examination besides the demand for active participation. from group to group and each FirstQuest-project is like a unique course, where the supervisors are the key characters.

What is electrical engineering like? As it stands it is a very difficult question, but it is all the same one which every student should have the opportunity to search for an answer to. FirstQuest is a platform for such a quest. By with a senior teacher the student has contact with someone who can gudie the students into close encounter of the third kind with the subject. Since the supervisors are free to design their contribution after their own minds it is very important to formulate common goals for all projects within FirstQuest. This goal-seeking is an ongoing process where the participant teachers are all invited to contribute. A central goal is to motivate students, and we believe that the

engagement of enthusiastic supervisors should act to stimulate this motivation. This goal is inspired from the aim of arousing "intellectual excitement" described by Stanford Introductory Seminars (SIS).

A very important aspect of FirstQuest is that the students are visible. A small group of fellow students and a teacher will take notice of you, and if you are missing, someone will ask for you. If you do not fulfil your assignments, the other group members and your supervisor will be concerned.

In a questionnaire after the course, the students give positive feedback on the social function of FirstQuest, which is gratifying but expected. What is more problematic is that many students find no source of motivation for their engineering studies within the frames of FirstQuest. Students actually critisize the fact that FirstQuest steals time from for example mathematics, so that the complementary nature of FirstQuest is seen as a competitor for the student's time rather than as the sought for alternative activity. It is as if the highly focused attention demanded by the intense first period obscures the broader perspective. It would be interesting to correlate the inclination to drop off with the attitude towards FirstQuest.

RESULTS

The results of our efforts to break the negative trend and improve student success will be discussed in this section. In Fig. 7 we show that despite the negative trend in the number of first-hand applicants per seat the average production (measured in credit units per student) is going up.

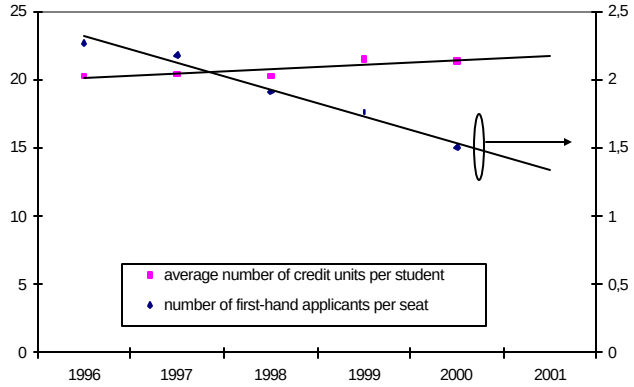

FIGURE 7.
THE AVERAGE NUMBER OF CREDIT UNITS PER STUDENT (LEFT AXIS) AND THE NUMBER OF FIRST-HAND APPLICANTS PER SEAT (RIGHT AXIS).

The results from the Calculus examinations during the last five years are shown in Fig. 8. Bottom columns (shaded) show the number of students who passed at the first examination. Top columns (white) show additional number of students who passed the examination later. The negative trend in the Calculus A and B examinations was broken in 1998. The suspicion that some of these improved results might be due to that these courses were made easier is contradicted by the results from the recent Calculus C (midterm) examination. This course also shows improved results even though some of the difficult material from Calculus A and B was moved to this course. Even if it is too early to cheer, these results show that negative trends can be broken if proper action is taken.

Error! Not a valid link.

FIGURE. 8
EXAMINATION RESULTS FROM THE FRESHMAN YEAR CALCULUS COURSES DURING THE LAST FIVE YEARS.

ACKNOWLEDGMENT

Chalmers Stiftelse is acknowledged for supporting this project financially. Titti Wahlström and Lilian Sandström are acknowledged for their support and participation in the project. Professor Holger Broman, Dean of the School of Electrical and Computer Engineering is acknowledged for his support of the project and his never-ending enthusiasm in discussions with students and teachers. Former dean, professor Olof Engström is acknowledged for initiating the Strategic EE/CE-project within which some of these activities have been financed. Professors Bertil Svensson and Björn von Sydow are acknowledged for many stimulating discussions when the EE and CE programs were compared.

REFERENCES

[1] Martin, D., Supplemental Instructions, University of Missouri-Kansas City.

[2] Grevatt, W., Early Warning Systems, AIM Student Retention Systems, Los Angeles, California.