# REDESIGN OF INTRODUCTORY COURSE IN ELECTRICAL AND COMPUTER ENGINEERING AT STAVANGER UNIVERSITY COLLEGE

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***Abstract*** *— This paper discuss the process involved in redesigning the curriculum in the Electrical and Computer Engineering department at Stavanger University College in Norway. The paper discuss briefly how the college preparation in Norway has changed in the past 25 years in Norway pointing us to revise our curriculum in a non-evolutionary way. In our case we are as a first step totaly revising our introductory course from a brick-on-brick (teach basic skills) to a top-down course hoping to motivate our students to continue and to seek a deeper level of abstraction necessary to solve engineering problems they will face after graduation. The paper outlines the process and the current status of the implementation.*

*Index Terms — curriculum overview course, instill excitement about subject, exploit synergy in department curriculum, meet student expectations.*

## INTRODUCTION

In engineering education we are today faced with the following challenge:

> The number of jobs requiring an engineering education continually increase while the total number of students "capable" of successfully completing an engineering degree is at best constant.

In this statement we have primarily considered the western world and the assumption that little has changed to engineering education (besides increasing capacity) in the same period. There are clearly student resources in the world largely untapped that will partially make this statement false. However, increasing the number of students taking higher education globally will also to some degree increase the number of engineering jobs requiring such an education cancelling some of the net effect of the increased number of qualified students.

To combat this trend most higher education are looking at ways to redesign their engineering programs. However, this alone will probably not suffice but is nevertheless a necessary process. Hence, about two years ago – fall of 1999 – a process started within the department of electrical and computer engineering (ECE) at Stavanger University College that is now nearing the (first) end. The process that started involved revising the entire department of electrical and computer engineering curriculum. The process was initiated partly to streamline the curriculum and partly to address a growing concern related to a number of years with poor student recruitment. Student recruitment does not seem to be unique to our institution and it seem to be a general decline in the interest in studying mathematical sciences and engineering. In the initial phase of the process a number of key questions were asked:

- Are we properly preparing students for the work force?
- Has the quality of the students changed?
- How/When is the department first seen by our students?
- What are we doing to motivate/inspire students?
- How are key topics introduced to students?
- What should/can we teach students in a first course?
- Do we need a new introductory course?
- Top-down (breath) or bottom-up (basic skills)?
- Level of abstraction in engineering curriculum?
- Are (information) technology used in the education?
- Are industry satisfied with the current graduate?

In attempting to answer these questions a number of discoveries were made both about the existing curricula as well as about the people making up the system – students, faculty and staff. In developing a new curriculum it was important to consider each of these questions and then determine if in fact changes were needed and if so how should we change the curriculum. We will not directly answer each question here but rather discuss the parameters and outline some of the factors we have to consider in answering the questions.

Another observation worth making at this point is that institutions are fighting to attract more students (preferably the best). To address this we have in the past continually made an effort to upgrade parts of our electrical and computer engineering curriculum. However, this has traditionally been achieved by replacing senior electives with more up-to-date senior electives (evolutionary change). Little or nothing has been done at the introductory level of the curriculum (step change). As a part of a larger curriculum redesign, we are

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now approaching our fundamentals course in classical circuit design.

Revising the curriculum or starting such a process is by no means unique to our program and when appropriate we looked at other programs. For a number of reasons (one being that we have a strong signal processing faculty in our department) we have in particular considered experiences gained at Rice University [4, 3, 5] Georgia Institute of Technology [1, 6], University of Illinois, Urbana-Champaign [7] and Ross-Hulman [8] all in the US. However, these are also experiments in various stages of developments started for different reasons and it is therefore important to remember that there is still no proof of an "optimal solution". Key to initiating changes in each of these programs seems to revolve around two factors:

1. A few (one or two) dedicated faculty members willing to take on the challenge involved in redesigning the introductory course of the curriculum.
2. Support and accept for changes in the introductory course.

While each of the programs have chosen different models for their first course they nevertheless have in common moving away from a bottom-up circuit course towards a breath (system approach and high level concepts) first course.

The goal everyone seems to be targeting is a new course given in the first year of study aiming to inspire and motivate students for a higher level of abstraction in later course work. It also seemed to have generated new excitement amongst the faculty something that again will reflect positively on the student in the classroom. An interesting observation made at Rice University is undergraduate students now taking part in research projects and even coauthoring conference articles.

## STUDENT PREPAREDNESS FOR UNIVERSITY

While there might be a number of reasons for needing to change the curriculum it is our opinion that one of the key factors are a general change in the background/quality/motivation of our entering students. It is not clear that students are prepared to survive a complete bottom-up (brick-on-brick) curriculum.

A phenomenon that might be somewhat unique to Norway in this regard are significant changes in the high school system, a process that started about 25 years ago. Prior to the changes Norway had a limited capacity "elite high school" system (Gymnas) mostly attended by few students with high marks from their secondary education. These students were very motivated and had decided early in their secondary education that they wanted to study beyond a high school degree. In parallel with the university preparation going on in the high schools, Norway had an educational (1-3 years) system training students for a profession.

Today this has completely changed. First, the two systems has partially merged, and second the capacity of high school is such that nearly everyone is accepted into a local high school program. As a result we have a de-facto compulsory (not compulsory by law) high school education (10+3 years of pre-college education). Furthermore, the new high school has great opportunities to elect away math and science (there are a lot of profession focused training in high school). In the new high school system students can elect to study for a particular profession at the expense of reducing the amount and level of math and physics courses. Students that plan on continuing for a university level science or technology degree must take math and physics during all three years in high school.

While this process of change in the high school system started about 25 years ago little seems to have been done (besides evolutionary) to adjust to the changed student composition at the higher educational institutions receiving the new high school graduates. There are also limited possibilities for filtering during admission based on grades since there is a centralized admission process for all the engineering colleges in Norway and there is a relatively low number (typically less than there are allotted student spaces) of applicants placing each individual college as their top choice. As a result we admit a freshman class every year with students that barely passed their high school diploma to the very best student. It is our subjective opinion that the average abilities of the students in math and physics are slowly eroding. Supporting some of these claims are statistics showing that in the past 25 years the number of students in Norway in post-high school education has tippled [10, 9] while at the same time we have only had a modest increase (12%) in the population. During this same period the age group 10-29 has declined significantly increasing the percentage of high school graduates entering college.

To compound the problem further the government in Norway has significantly increased the number of allotted spaces for students the department (IT boom) should accept into the program. Coupling this with an overall decline in high school graduates with poorly trained/motivated high school graduates (result of a compulsory system) one has to accept that the student body entering a college education has significantly changed. This does not mean that there are not good students in the system – just that the mean student that enter our system has changed significantly (not the least their motivation).

To summarize we observe that in the past (in Norway) the high school worked as a filter. This filtering operation is now moved *into* (not in front of) the colleges and universities. Since education is clearly not a linear system the end result, without significantly changing the university curriculum, is very different upon graduating from the university now compared to 10-20 years ago (ignoring how technology has impacted us).

There is also an increasing pressure to correlate government funding for the educational institution (Norway has a non-tuition based university system) with the institutions ability to produce graduates at the same rate as they enter the system. To cope with this we have to find alternative methods for motivating students to want to learn and for the students to find it interesting to study. The university must find ways to bridge the student from the secure educational environment of the high school to the sometimes very anonymous university environment.

In this scenario it is our belief that a classical curriculum is far from optimal given the current student body (above discussion) since it is entirely bottom-up with little room for answering questions from students of the form: Why do I need to learn this? The answer that once always seemed to work however pedagogically wrong – "just wait and you will see why this is useful" – is not a good alternative with less motivated students.

### What is down the road

Soon to add to this complicated picture entering the universities are students graduating from high school following a reform in the entire 10+3 year education system in Norway. This involves a focus on top-down teaching and project based learning. We don't know enough about this yet to make any further comments – but it will impact the higher education in one way or another.

## INDUSTRY NEEDS

Industry needs represents the big unknown in this process and asking different representatives of the industry on different occasions we get very different answers on what they want students to know. The only statement you can safely expect to get from everyone is: "the student needs to know their basics, have good problem solving and communication skills." On a number of occasions we have tried to get a refined understanding of what they include in basics. However, one soon discovers that it always includes good math and physics skills and a circuit like course (typically because they had this themselves and hence think of it as basic) in addition to programming skills (this everyone has to have today). Seldom do you get replies indicating that there is something wrong with the curriculum or answers that suggests we should change. This could imply they don't know what should be done or that the system (in particular the students) as we know it are pretty robust.

However, there are exceptions, and in that regard it is quite worthwhile to read a short paper by Gene Frantz [2] where he as an industry representative asks some interesting questions that we as educators often do not consider – or at least easily dismiss. In the article Gene Frantz also warns against educating in silos and encourages to broadly educate students something very concrete to include in any curriculum discussion.

## THE DEPARTMENT

Stavanger University College as it exists today was created through two merger of different educational institutions. The first merger creating what today is primarily the School of Science and Technology took place in 1986. Following that merger a number of additional educational institutions merged again creating four more schools in 1994 and giving raise to Stavanger University College. However, the roots of engineering education (training) goes back to 1944 and the "technical school" that then existed in Stavanger. The department of Electrical and Computer Engineering was formed in the merger in 1986 and is now the largest department (counting students) in the School of Engineering. The department has 20 full time faculty members and four adjunct faculty members. Annually the department graduates about 120 students from the three year undergraduate engineering program. The department offers majors in "signal and communication technology," "software technology," "control technology," "medical technology," and "power engineering." In addition the department has a graduate program in information and communication technology. In the graduate program we annually graduate 30-40 master level students and 1-2 Ph.D. students. The Ph.D. program was initiated in the early 1990s and have seen a steady growth of activity.

### The curriculum - past and future

During the first year of study at the students are offered a mixture of courses in mathematics, physics and chemistry building and reinforcing their high school fundamental skills. As part of the engineering curriculum we have in the past offered (first semester course) an elementary introductory course on computers (interplay between hardware and software, 1's and 0's, computer number representation, etc.) followed (second semester course) by an introductory programming course (Pascal, C, C++ or JAVA depending on when in the past). Both these courses are mandatory for a large portion of the School of Engineering and are hence teaching basic skills all students need and are not suitable introductory course for the ECE department (with the possible exception of the software engineering majors).

As our electrical and computer engineering introductory course we have (as most institutions) always offered a classical circuit course. In the circuit course the students get introduced to what once was hard core electrical engineering fundamentals. The course served to introduce students to elements of electrical (and computer) engineering relevant for their later course work and was the natural first true meeting between the department and the student. Beyond the introductory course each major followed natural, somewhat classical curricula, culminating in a capstone design project. To keep the curriculum "up to date" and to market the program occasional new courses has been introduced at the senior level replacing less "in-time" electives (giving a boost to buzzwords that could be used in describing the curriculum). These were typically filtered down from the graduate program or developed based on special interests of individual faculty members. Besides these senior level electives little non-evolutionary change has taken place in the program.

However, several aspects of electrical and computer engineering have changed the last two decades – not the least being the students entering the education system. With this in mind we set out to develop a new curriculum for the department.

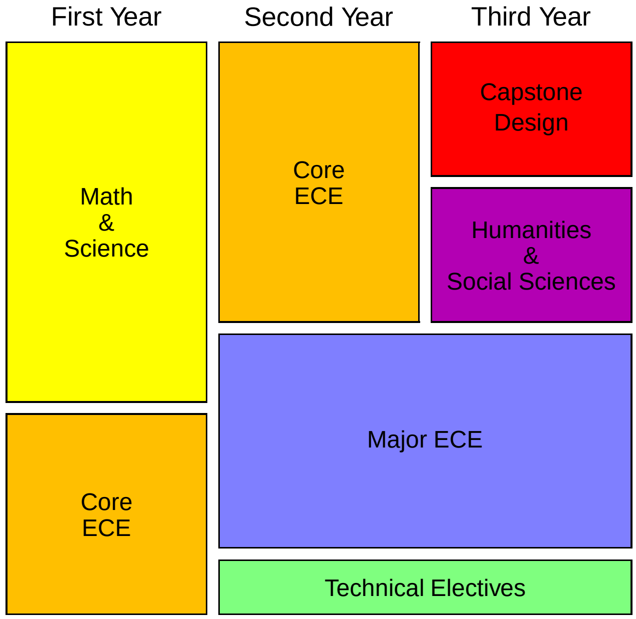


Figure 1: New electrical and computer engineering curriculum framework.

In Figure 1 we show the framework for our new curriculum. Each year represents 20 credits tough on a two semester system. Prior to this revision there was less correlation between the different majors.

## COURSE ESSENTIALS

In lack of a better name for the course we have elected to call our course "Introduction to ECE." This title represents what we are trying to achieve with our course – introduce the field of electrical and computer engineering to our entering students using a breath/top-down approach. The course represents $\frac{3}{10}$ of a full semester load and will include a hands-on laboratory sequence integrating the computer as a measuring and processing device on the laboratory workbench.

Introducing the computer as a tool to learn with rather than as a "device" the student should learn everything about seems only natural given the high number of students having had access to a computer for years prior to entering college. Our challenge is then to find the balance between underestimating and overestimating the students ability and motivation for using the computer as a tool in their education for engineering purposes. Our current limited experience seems to indicate that there is a significant barrier with our students in converting from considering the computer as a fancy game devise/office organizer to that of using it actively in their education (not just for writing reports).

The new introductory course will emphasis concept like (digital) signals and systems, frequency analysis at a superficial level while maintaining some of the classical circuit course – necessary for later course work. We will use realistic examples/systems (both in class as well as in the lab) drawn from the different majors as demonstrators for these concepts. Circuits will be introduced as a means to solve practical problems rather than as a skill (on its own) to be used later (the skill level for later courses should be a by-product, not the primary objective). Theory and details of key concepts will be introduced in later courses when these concepts are familiar (superficially understood and its importance appreciated) to the students. Reordering the introduction around a top-down approach will hopefully motivate the students to approach the material at a higher level of abstraction.

The course will be offered the first time during the spring of 2002. As a result we are currently working on defining the details of the syllabus. We will during the summer 2001 design most of the laboratory exercises and prepare facilities for the laboratory (this is a major undertaking given the different approach this lab will take compared to previous labs we have had). The plan is to build 20 identical laboratory workstations where students can work in teams of two/three students. We hope to let the students have access to the laboratory both during arranged laboratory hours with an assistant as well as during other open hours.

One additional and significant change in our laboratory will be to place a lot of emphasis on preparation for going into each lab rather than our traditional post-lab report. To this end we are working on implementing an internet based laboratory preparation system as part of our online class modules. Through this system the students will be able to access and complete an organized pre-lab problem sequence tailored for each laboratory exercise. We are also evaluating software that students can use either on their home computers or on the net in preparation for class and laboratory.

The traditional post-lab report is still important but will not be used in this course. Instead we plan to replac the report with an in-class followup discussion relating experiences form the lab to in-class material and homework assignments. This post lab organization will also enable us to engage the students in verbal communication – a skill that frequently is neglected in the engineering curriculum.

## SUMMARY

In this article we have discussed the parameters involved in revising the electrical and computer engineering curriculum at Stavanger University College in Norway. We have in particular looked at fundamental reasons for such a change. One of the key observations/arguments is that the high school graduates today is very different from 25 years ago. As a result we need to revise how the students are bridged into a college education. While there has been a continual evolution in the curriculum during this 25 year period we now propose a step change early in the curriculum that is targeting the skills our freshmen students have today. As a first step we are proposing to implement a top-down introductory course that will help motivate the students for continuing to a deeper level of understanding. This is not a revolutionary proposal as this has been tried at several institutions but in this case we argue that there are key factors in the college preparation that strongly motivates our proposal. We will continue the process and courses following the introductory course will be revised to compensate for the new set of skills we teach.

## ACKNOWLEDGMENT

We would like to thank our colleagues in the department for taking the challenge involved in revising the curriculum. Such an effort can only be undertaken with broad support, commitment and a large degree of consensus. Changing a curriculum is always a challenge since it touches with every person in a department sooner or later. The first author would also like to thank Professor C. Sidney Burrus and Professor Don H. Johnson at Rice University, Professor Jim McClellan at Georgia Institute of Technology and Professor Dave Munson and Professor Doug Jones at University of Illinois, Urbana for numerous interesting conversations on curriculum changes and first course experiences.

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