Simplifying Paths to Mastering Embedded Systems

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***Abstract*— The engineering degree programmes in Helsinki Metropolia University of Applied Sciences have gone through a fundamental change. The number of degree programmes has been reduced from 20 to 7. The reduction was based on an analysis of the tuition of the previous degree programmes. There were quite a few different study paths that a student could take to gain certain professional skills. Some of these paths required applying to certain degree programmes thus requiring quite a lot of insight of the field of study even before applying to the university. Smaller number of degree programmes allows students to pick the field of study they are interested in still leaving them with a lot of flexibility later in the studies. The analysis also showed that different degree programmes offered courses or modules with identical or very similar learning goals. These modules were merged and are now shared between programmes. Reduction in the number of degree progammes was not the only change. There was also a major change in the way the tuition is organised. In the new curriculum courses are given in modules of 15 ETCS credits. Each module lasts 10 weeks and targets in students gaining or deepening professional skills in the area covered by the module. The key idea of these large modules is to bring project based learning as an everyday practice in engineering education and to integrate basic studies into the projects instead of having separated courses on for example maths, physics or communication skills. This article focuses on changes made in the curriculum of students majoring in embedded systems.**

Keywords—integration of studies; collaborative teaching; project based learning

I. Background

The major restructuring of engineering degree programmes in Helsinki Metropolia University of Applied Sciences was sparked by couple of events that have had or will have an impact on the funding of the university. Metropolia was formed a as result of merger of two universities of applied sciences where both had existing engineering programmes in same fields of study in addition to large number of other degree programmes. Currently tuition is given in quite a few geographically separate campuses. A project to reduce number of campuses has been started but a project of moving staff, facilities and thousands of students around will take a number of years to complete.

The funding of universities has undergone a number of changes during past two years and more changes are on the way. The outline of future changes is roughly known (budget cuts) even though the details are still under political discussion. In addition to budget cuts the way funding is allotted to universities has changed dramatically. In the new system the size of the allotment is mostly based on the number of graduates and the number of students that make at least 55 ECTS credits a year. There are other factors that are accounted for as well but their weight is significantly smaller compared to the weight of the previous two.

Tuition has been (and still is) organized so that each student had a possibility to complete 60 credits a year. Previously the most common size of a course was 3 credits which meant that a student failing two courses (out of average 20) would fail to reach the 55 credit goal as well. A failed course also meant missing prerequisites for the following courses which impacts plans for the following year(s). An engaged student with a strong will to do planning on his/her own can make up the missing credits the following year. However in most of the cases the missing couple of courses from previous year will lead to missing couple of courses the next year as well; either due to missing prerequisites or conflicts in the schedules.

It was noted that a substantial number of failed courses was the basic studies in mathematics and physics. Students often fail to see the value of engineering mathematics and physics for their professional studies which may lead to lack of motivation and increase the possibility of dropping the course.

Students have been encouraged to select studies from other degree programmes to broaden their professional skills. In practise this has been very difficult to implement due to many constrains; schedules of each programme are planned for students with major in that field of study, there are typically prerequisite courses to take in order to have a minor in another field of study and the minor and major subject can be on a different campus which makes planning even more difficult.

II. Integration of Studies

Metropolia engineering programmes have adopted CDIO as the frame work for education of engineering students. One of the goals of CDIO model to is to bring team work and practice back to the engineering education [1]. That is an important goal especially for a university of applied sciences whose main goal is to train engineers with up to date practical skills along with theoretical knowledge and interpersonal skills.

There have been large number of studies on the problems in engineering education and many of the proposed solutions are in line with the CDIO model. One of the issues to be addressed is too intensive focus on the content which reduces students possibilities to put his/hers knowledge into practice. Concentrating on the content also limits learning social skills that today's engineer needs. Working in a theoretical and teacher centered environment offers limited experience of team work and does not give an insight into the social aspect of engineering work [4][5].

Basic studies of math and physics are now integrated into larger study modules with multidisciplinary approach. Each study module of 15 credits has professional learning goal(s) and the integrated basic studies are intended to support the professional studies (and vice versa). Each module is assigned a team of instructors that plans and organizes the tuition of one module and is responsible for assessing the module as well. The modules are (mostly) assessed as one entity so there will be no separated grades for each field of study in the module.

III. The Structure of the Curriculum

In the new curriculum all tuition is organized into study modules of 15 credits. Each module lasts 10 weeks and each year of study consists of four modules making 60 credits a year. The first year of study in the degree programme in information technology consists of common studies and after the first year the students decide their major field of study. The four modules of the first year introduce the students to the majors available in the degree programme. The basic studies (math, physics, communication skills, etc.) of the first year are integrated into these four modules. Each module has a theme that relates to one or more majors available.

The module that introduces embedded systems is called Robots. As the name states the theme of the module is a robot and in the module the students get to take a peek into the field of embedded systems. In addition to programming an embedded system they'll also see that they need skills in maths, physics and electronics as well and also acquire some of those skills on the way. The module, like all first year modules, employs inductive teaching methods [2]. The students start with a problem and work their way to theory instead of starting with theory and working their way to applications of the theory [3].

Dividing the academic year into four 15 credit modules is intended to help students to plan their study paths and to reduce redundancy in the courses offered by degree programmes. The modules that are applicable to many degree programmes are now planned together with the applicable programmes and are given only in one degree programme. Since the module occupies the whole 10 week period there is no need to merge schedules and it does not matter if the module is given on a different campus. This makes planning much easier and reduces the possibility that a student can't take or has to drop a course because of conflicting schedules.

Figure 1 illustrates the conflicts in schedules that can arise with overlapping modules. If modules are not given on the same campus the required slack for transferring between campuses increases the likelihood of conflicts. Figure 2 shows how shorter fixed length modules solve the scheduling problem. Since one module occupies the whole 10 week period the student doesn't travel between campuses during the day and there is no need to resolve schedule conflicts.

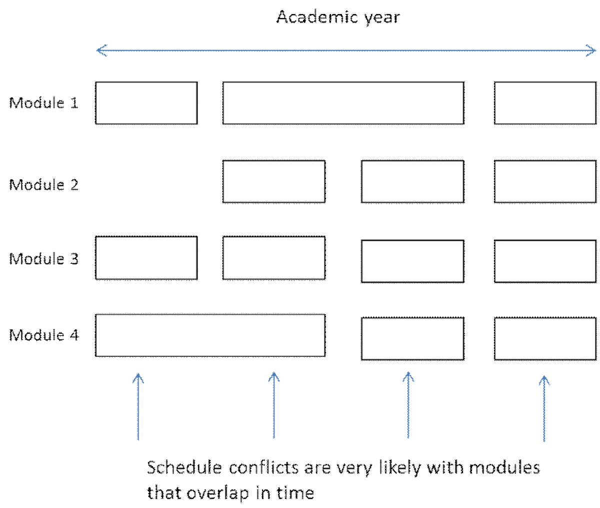

Fig. 1. Old curriculum with modules of varying length

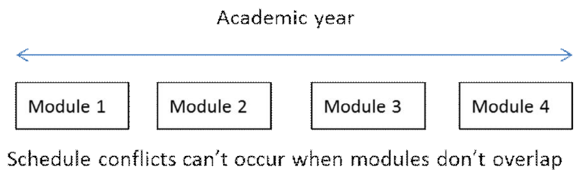

Fig. 2. New curriculum with fixed length modules

Large modules don't automatically solve the problem with prerequisites for taking certain modules. Prerequisites can prevent a student from taking certain module at a time he/she wishes. With 15 credit modules to reach the yearly 55 credit goal a student must be able to take four modules per year which emphasizes the importance of careful planning of study paths in the curriculum. Study paths should be designed in a way that makes them flexible and allows interdisciplinary studies still ensuring that every student can take four modules per year.

In the previous longitudinal organization of modules the number of prerequisites for a module could be kept to a minimum by arranging courses so that student picked up the skills needed on later courses from the earlier courses of the module. When the time frame of a module is fixed to one quarter of the academic year the learning objectives and prerequisites must be analyzed very carefully to prevent creation of bottleneck modules [6]. Interdisciplinary studies must also be accounted for since it is not feasible to require a student with a major in another degree programme to complete a large number of supplemental studies before taking a minor. Embedded systems modules were designed so that there are no other prerequisites except the basic programming skills. This allows a student to take the embedded systems modules in any order and makes it easy for other student to take the modules as well.

A study path of an embedded systems engineer has a lot in common with a study path of a software engineer. Both need for example basic programming skills so software and embedded systems engineers can take the same programming module which reduces redundancy since there is need to give only one programming module. Figure 3 shows an example of embedded systems engineers study path. Vertical arrows depict that the student can choose which modules to take. For example a hardware design oriented engineer can take electrical engineering module and software oriented student can take software engineering modules in addition to embedded systems modules.

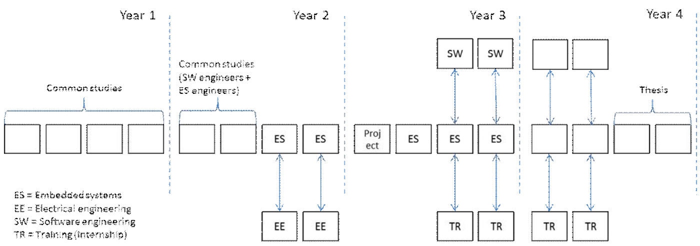

Fig. 3. An example of a study path of an embedded systems engineer

IV. SUMMARY

Curriculums of engineering students have been completely revised and the new curriculums were adopted this academic year (2014 - 2015). The revision aimed to address several issues that delay students on their way towards bachelor degree. The goals for the new curriculums are:

- Increase the number of students that make 55 credits a year
- Reduce redundancy in modules
- Increase the amount of problem based and project based learning
- Create a strong link between basic studies and professional studies
- Make interdisciplinary studies easier to take and schedule

As of this writing the first module of the academic year is coming to an end. Preliminary results indicate success in many of the goals above. However we need to wait for the whole academic year to end to have more comprehensive statics to analyze. They will be analyzed objectively and in great detail to provide feedback for the further development of the curriculum.

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