Motivating students in engineering & ICT education

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abstract

We found out that 25 % of our students came to study at the Electrical & Electronic Engineering department (E&E) because they were active (as a hobby) in music. Because of this the E&E department offers their students to work in video and audio themes in all projects of their education. From our inquiries we found out what students interests are and we use these interests for new project themes. The study has been changed in such a way that it is possible to have these project themes twice in every semester. Amongst them are, besides music, e.g. medical, sports, automotive and mechatronics.
Other inquiries show that 47 % of our students choose for ICT because they are interested in computers or programming or do this for their hobby. Inspired by this the ICT department defined four new fields of interest: game design, management & security, mobile computing and life style.
Both E&E and ICT connect the projects in their courses directly to industry and in this way students and lecturers are intensively involved in industry. From two surveys we learned that working this way is an excellent way to get students motivated and gives them drive and enjoyment in their study.

keywords: engineering motivation, industrial projects, innovation, students' hobbies

1. INTRODUCTION

In the last decade the student numbers in engineering have been decreasing. Therefore Dutch national and local programmes have started to show pupils in primary and secondary education what technology is and how much fun it can give them to work within this field (see also paper of Dick van Schenk Brill at SEFI 2009 to see what has been done so far).

Fontys Engineering and ICT have changed their curricula in 2007 in a specific way with the goal: how to keep young students attracted to engineering? In other words: what to do to keep them motivated, once enrolled?

2. FIELD OF INTEREST

Until 2000 the first two years of the E&E engineering education the program was quite rigid. There was no space for open ended and free projects because the projects were linked to the theoretical courses. Only in the third year there was project time available for more open ended and integrated projects. For these projects students could choose their own themes. In 2000 the Fontys E&E department started looking for more attractive and student inspiring projects. At that time we found out that 25 % of our students came to the E&E department because they worked at home in the music scene. Playing live music (guitar, drums, keyboard), being a DJ or VJ in their spare time or working as a technician at live shows. It is no surprise that when introducing projects with light and sound aspects the students highly appreciated these projects and were excited about them.

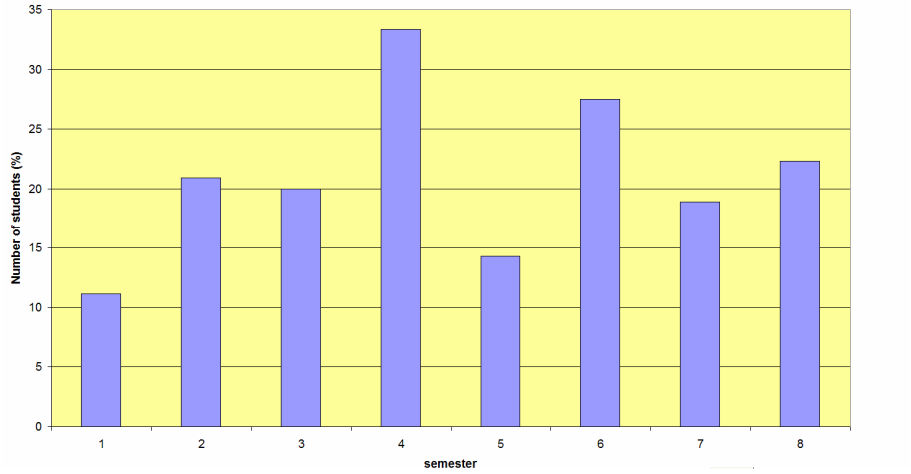

Figure 1. Percentage of music oriented students in all 8 semesters

Since then the E&E department offers students to work in light and sound themes in all projects of their education. We have changed the study in such a way that it is possible to have these projects in every semester. In Figure 1 one can see the number of music oriented students who came to our study because of this opportunity of developing products related to their field of interest. 20 % of our student population at the E&E department came to the department because of this curriculum reform. Of course we are not educating “music engineers” who can only work in the music scene. By working in this way we educate much better engineers. In an average project students often are satisfied with a ‘sufficient’ grading. However, students working in a project where one can ‘hear’ or ‘see’ the final product or prototype are

much eager to reach the top. The sound (and/or vision) should be superb and they all attempt to achieve an 'excellent' grading. Just the subject drives the intrinsic motivation to a much higher level, and so to an engineer delivering a really higher output standard compared to the average engineer.

3. SURVEY

Due to this success we have inquired the students at the start of their course. Each year the first year students were asked what their motivation was to come to the Fontys University. In Figure 2 one can find the outcome of these surveys held in 2006, 2007 and 2008. In this figure the outcomes of these three surveys are summarized. The total number of students participating in the survey was 163.

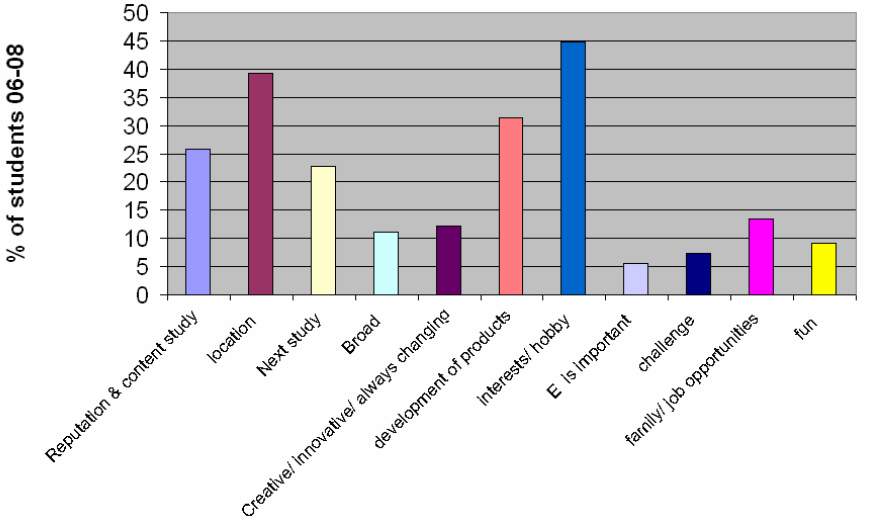

Figure 2. 11 Reasons to study E&E

In the Netherlands 'normal' reasons to choose for a certain university and/or department are: reputation, location and next study based upon their study already finished. With 'reputation' we summarized how famous and well known is the education and which are the course programmes? With location is meant: the student indicates that the university is easy to reach (by buss/train/car/bicycle) and with 'next study' it is meant that the student has finished a secondary technical education and continues at a bachelor level.
More important are the other eight characteristics measured because here one can directly interact with the students' interests and hobbies. The highest score is found in the field of interests and hobby. It shows that 45 % of the 163 interviewed students is very much interested in electronics. They are eager to learn more about it.

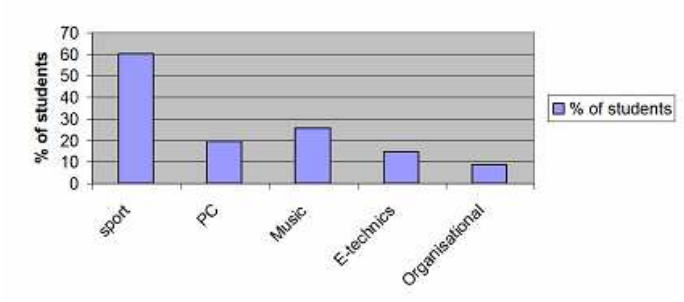

Figure 3. Hobbies of the E&E students

In the inquiry it was also asked which hobbies they had. In Figure 3 one can see where the students are specifically interested in. The already discussed interest in audio and video is still present (26%). But more important is the great interest in sport. From all the students 60 % sports on a regular base. Furthermore is the PC (13 %) and just working with electronics (15 %) an import part of their life. The last significant hobby is being part of organisations like being a leader with scouting groups. This information helps a lot defining what kind of subjects attracts students in their study. We thought that working in the field of his interest will help the student to feel comfortable, to work with the drive to successfully accomplish the given assignments.

Going back to the reasons for choosing the E&E study (Figure 2) one can see that a first year student is really eager to work in his field of interest. He wants to be

- a developer of new products
- to act as an innovator
- creative and
- working on new, always changing subjects.

To keep students attracted during their study we have to make it possible that the students are exploring the world as innovators.

4. START WITH INNOVATION

From the survey we learned that 31 % of our first year students came to the E&E department to learn to develop new products and 19% of the students with a technical background had special interest in innovation and finding creative solutions in product development. In the study however everything was focused on: learn the theoretical background first and after that and only then one could start with practicing in product development. In the new curriculum we changed that focus and start with innovative project work right from the start. The students learn in their first semester, how to work in teams by developing their first real product. This development is based on existing technologies and schemes.

In the second semester they may choose to work on a project named "The Invention." This is a project with Mechanical and E&E engineers together where they design and develop an invention of their own. They learn that it is allowed to use (parts of) developments from other engineers to implement into their own product. In projects further on in their study the contribution of own developments increases rapidly. First year students show at the end of their year the products to a big audience of parents and friends. Here the most innovative product is rewarded. But not only are the winners really proud of their work and achievements. All groups show great pleasure and pride in their work. Working with product development from the first year onwards is an excellent way to get students motivated.

5. WORK WITH INDUSTRY

Within the E&E projects the chosen project themes are close to interests of the students. These project themes are:

1. Sport Technology
2. Medical Technology (related to the interest in sport)
3. Automotive (related to the interest in electronics and cars)
4. Mechatronics (related to the interest in electronics)
5. Audio and video
6. Installation technology (related to the interest in electronics)
7. Business, economics and technology (related to the interest in working organisational)

In our new programme 1/3 of the study load (credits) is spent in project work. Where the first year projects focussed on inventions and creativity, in the second year these projects are closely related to the industry and focus more on design and development. All is organised in the so called eXPo-projects: **E**ngineering e**XP**erience **O**rganisation. All projects (about 40-50 each semester) are open ended and new: for the first time carried out by students, coaches and industry. We have asked the 40 E&E students what their view was on the project work and set up of it carried out in the autumn semester of 2008. We had a response of almost 50%. Figure 4 shows that the students really want to work with new developments, projects with an open end. It scores a 4.4 on a scale of 1 to 6.

It is important for me to develop every time a new product. That is why I want new projects which are open ended (n=19).

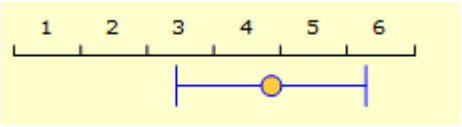

Figure 4. Importance new projects

Each student has indicated whether he wants to work in a specific theme. There is such a variation in projects that all students are able to work in their theme indicated. About 35% of the students have not indicated a preference. It is because they do not know yet what kind of expertise they want to work in.

The use of themes, in order to get a preferred registration in the projects which fits to my interests is perfect (n=19).

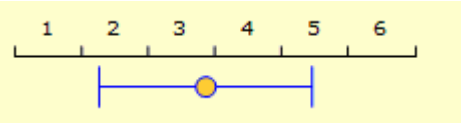

Figure 5. Themes in projects

The survey indicated that students do not put much weight on this issue: in fact many students do not want to be bounded by their theme choice (Figure 5) and many students switch to another project theme because that project is more preferable for the student at that time.

Everybody may come up with projects. We have some projects defined by our colleagues and by our students, but mostly we have subjects from industry. This was until now more or less random. In future we want to collaborate closely together with companies as "Partner in Education" or "Partner in Research." This is already implemented from September 2008 onwards at the ICT department. In this way Fontys is pulling the industry into the study and bringing them together with students and lecturers. It is our view that industry has to and can bring in their knowledge and expertise into the learning environment of the students. We now have 21 companies who signed a contract. Stated in these contracts is the involvement of the companies in the education of the engineers. These collaborations will start from autumn 2009 onwards.

6. OTHER CHANGES

The E&E department wants to educate product developers who are ready for the future. They will be needed in the region of Eindhoven where many companies work in E&E product development. We have to bring in the latest technologies into our education as there are controllers, FPGA's, EMC proven design, analog and digital design, wireless technologies and medical oriented design. Therefore a "body of knowledge" is important for our students. Only working in projects is not sufficient: one has to be able to make a perfect design. Mathematics, component knowledge, circuitry, programming, controllers, telecommunication and radiation are the basis for future development. And although students want to be an engineer in future, for some is the body of knowledge a hurdle hard to get over. For these students we

made different study routes. Each student has a counselor and together they can choose for a personal study route which e.g. is slower than the average student.

On the other hand we also have routes for excellent students. They are studying in the fast lane of our education and could get their bachelor in 3 instead of 4 years. Or they may choose for the excellent program (an honors' program) and do extra courses to prepare themselves better for master programs. With these new routes the number of enrolled students that obtain their certificate has increased and we do have one of the highest 'yields' of our university!

In the third and fourth year the students have their specialisation. They choose a more broad education by entering a minor of another discipline or specialization in the E&E discipline. The students also work as a trainee in industry for half a year and in the last semester again for 6 months working on their thesis. The student is free to choose specialisation, topics and companies where they want to do their work. In this time period the student has an intrinsic motivation to do the job. He sees the finish line and works in a context he likes most.

7. ICT EXPERIENCES

Also within ICT we tried to find out what arguments were most important for students to choose for ICT, for the actual ICT course, as well as for the Fontys University in Eindhoven. The results of enquiries for 100 students were analyzed. The arguments stated for an ICT education are depicted in Figure 6.

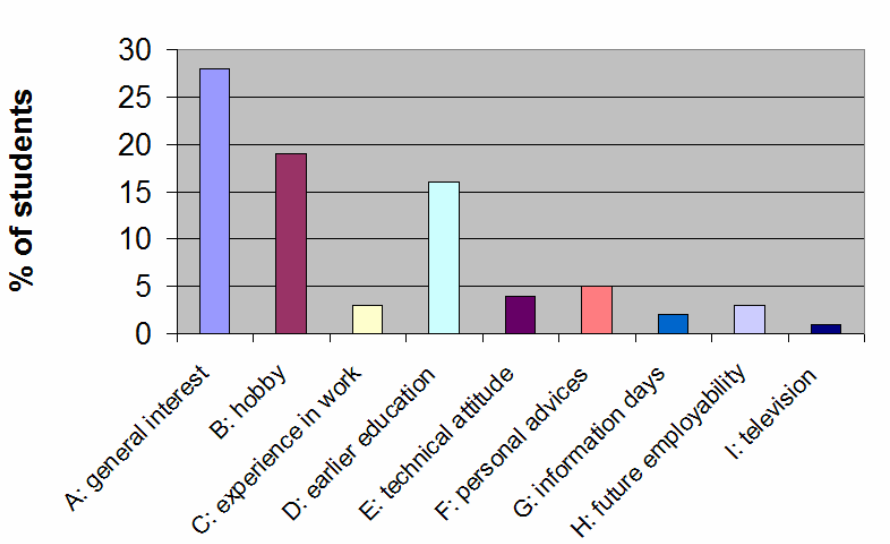

Figure 6. Arguments to choose for ICT

Although the way students were enquired differs from that within E&E, the results show a good correspondence. About 45 % of the E&E students chose for their education as a result of their hobby. In ICT this is 19 %, but if we consider the general interest in computers and programming also as a hobby (which was confirmed by talking to the students), the total comes to 47 %, which is quite comparable!
For about 22 % of the E&E students the earlier education (expressed as "Next study") was an important argument; within ICT this is 16 %, slightly lower. Other arguments can better be compared with the arguments that were given by the students for the specific course within ICT or the arguments for choosing the Fontys University. These arguments are summarized in Figure 7 and 8.

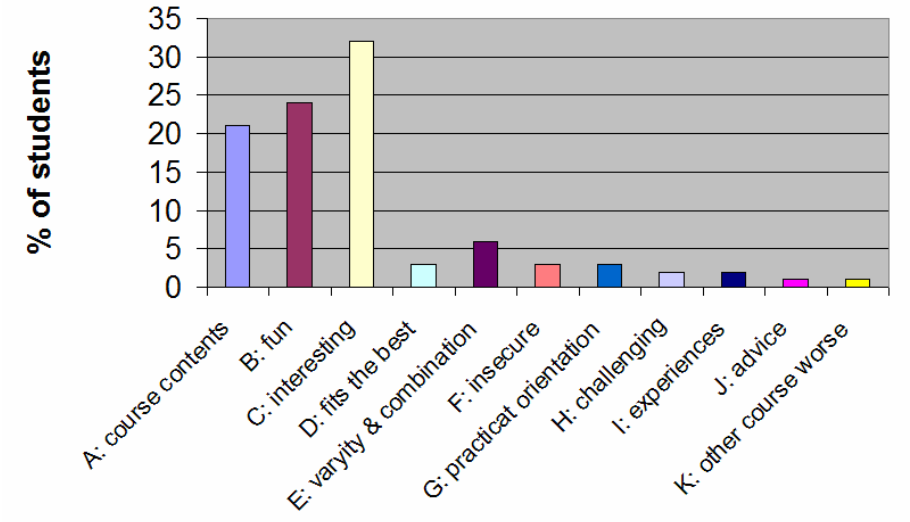

Figure 7. Arguments to choose for specific ICT course

In figure 7 A stands for arguments based on the contents of the course (e.g. wants to learn about media design or about software engineering). B means that the students thought the specific course was fun and with C the students classified the course as being interesting. Quite a number of other arguments were given, where only E (the variety of courses and the possible combinations) reached more than 5 % (actual 6 %). The interest in the contents, having a score of 21 %, is not subdivided. Besides arguments as wanting to learn more about software engineering, specific aspects of some courses were mentioned. A score of 24 % for B shows that the students really like their chosen course, almost all the students that mentioned that they thought it would be fun still think the same way now. This counts also for the 32 % of students that thought their chosen course would be interesting.

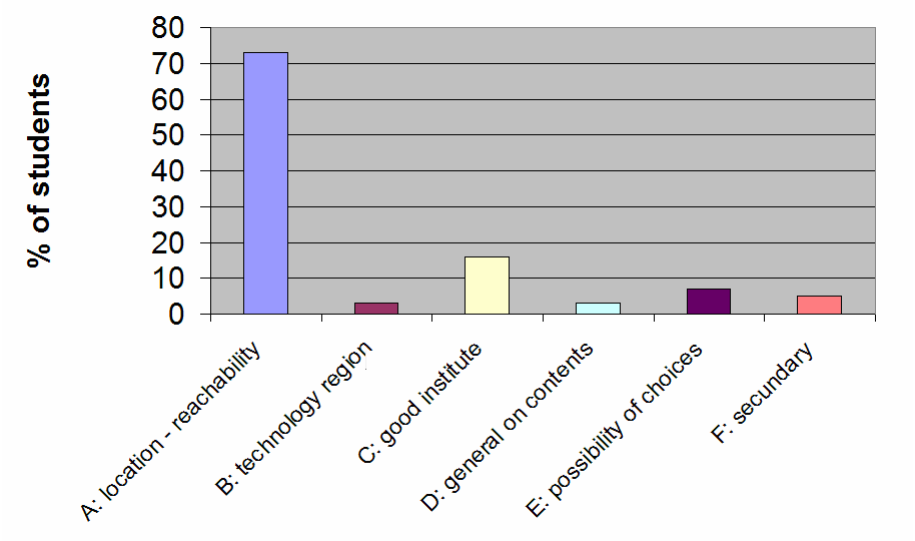

Figure 8. Arguments to choose for Fontys Eindhoven

In Figure 8 the arguments for choosing for Fontys Eindhoven are given. This confirms the results of E&E, where almost 40 % of the students mentioned the location as an important argument. For the ICT students the results here are over 70 % (A), but here the question was explicitly directed to the choice for Fontys Eindhoven, which leads to answers as "Eindhoven is a nice city", it is close to where I live or it is easily to reach by public transport. Fewer numbers of students interpreted this question as an inquiry for the quality of Fontys education in Eindhoven. This leads to 16 % stating, that the Fontys University was known as a good institute (C) and 7 % recognized that the Fontys ICT courses offered more variety and more possibilities to switch than comparable other universities within reach (E).

8. EVALUATION

The E&E department wants to educate product developers who are ready for the future. Working together with industry makes it all happen. We see a fast process of bringing new technologies into our learning environment. But does it help reaching our goal: attracting students to engineering? Therefore we present the first results of this way of working. It is a student survey of our E&E students (40) working in the eXPo projects as described before.

By using open ended projects students indicate that with each project they have taught themselves new techniques. 100 % of the students indicate they learned new topics in E&E to fulfill the project assignment. That is a great accomplishment because that is the start of a life long learning mentality for our students.

But what about the "body of knowledge": the courses given in first 3 semesters: are they of any use? Respondents are very satisfied with the usability of these courses as well. It scores a 4.3 on a scale of 1 to 6. We think that project work is a way to inspire the students and to keep them attracted to the study. That was confirmed by the students; over 80% told us, that they liked the project work better, compared to theoretical courses.

So our eXPo projects make it possible for students to show their competences: implement knowledge and skills and learn new knowledge and skills in a rich environment. That was just what we wanted educational wise. But we also had the goal to attract the engineer of the future and keep him engaged in engineering. So is the project work a way to inspire the students and to keep them attracted to the study. In Figure 9 one may see that the project work is scoring very high compared to courses (theoretical courses do have practical aspects in it as well!). The score is a clear sign that project work is a real asset for engineering education.

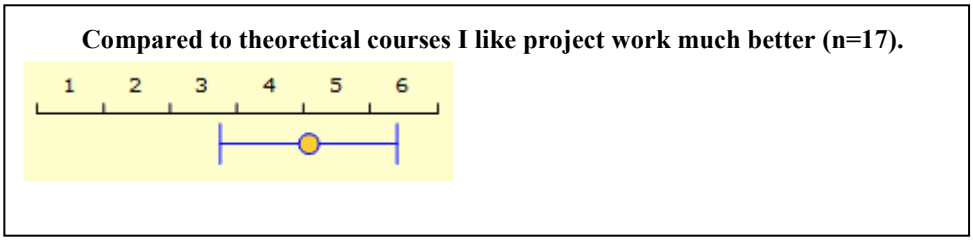

Figure 9. Project work versus courses

The last thing we checked was our main question: are students better motivated in proceeding their study because of the project work with industry. Here the score was slightly lower (4.2 out of 6), but still a good sign, that indicates our first ideas that this is the way to go! Besides the students also stated that team work helps them a lot in persisting in studying and staying at the university.

Also within ICT project work plays an important role. As there was no second inquiry, specially meant for project work in the ICT department no measured figures can be given. However, from discussions with students we learned that project work and the relation to industry with that were highly appreciated. Here also students preferred working in a project above "theoretical" courses. Considering the success of the E&E approach to start with realistic cases at the beginning of the study and come up with theoretical back ground later, the ICT department is carrying out experiments in the first year in a comparable way now. It is still too early to come up with results and compare the quality of what is learned to that gathered in a "traditional" way.

9. DISCUSSION

Of course there are questions to be answered in near future. Two main questions are raised. The first one is “what the influence is on the main change from “first theory, than projects” towards just the other way around “immediately start with design and development, theory comes later” as been carried out already in the first year. The discussion is “will the engineer of the future still be able (and willing) to calculate and design a new product himself instead of ‘Googling’ to find an answer (without even knowing whether it is the best answer?)

And the second discussion going on is whether projects, which are not directly connected with the theory given at the same moment, will make the student competent enough and aware of the practical side of the theory? As for now students indicate that in each project, all students learn new things in order to accomplish the project assignment. Further investigations have to find out whether they learn the things we really want them to learn. In that case this set up is great. Else we have to adapt it in future.

10. CONCLUSION

It is as Margaret Gildea, Executive Vice President of Human Resources (Rolls-Royce, UK) said: “Blending together the best of academic and applied learning, the qualification immerses young people in the excitement and potential of working in the real world of engineering. The experience will create a new generation of young engineers with a career head-start.“ [1]
It is proven by the outcomes of our latest survey on the eXPo-projects that working in innovative projects in the first year and with industrial projects in the second year really helps to get students attracted to their study. They see what will be asked from them in future, they know how companies work, they start with the life long learning concept and as we all know: team work is essential in the modern engineering world and by this students know it and are prepared for this way of working.
Concerning the ICT department; the first results (and comments) of the students indicate that the construction of four different courses from which it is easy to switch (as they are highly combined at the start) and the possibility to chose for projects that come close to the interest or hobby of the student is successful and leads to less depart of disappointed students. However further investigation in this field is needed in order to determine the real figures.
According a recent research of the National Academy of Engineering (NAE) [2] we just implemented what they propose to use in the communication towards the outside engineering world: encouraging young people to make a difference in the world. It is more likely to attract them with good projects and challenging them than emphasizing the challenge of math and science skills. Engineers make a world of difference and now they can experience that themselves from the start of their education.

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