VALUE OF STUDENT PROJECTS

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Abstract *¾ The paper starts with a short description of a model for project based learning used at Tromsø University College. Students have 20% project work in the four first semesters, 10% in the fifth and 50% in the last sixth semester. The final year projects are performed externally in collaboration with local industry. The students get professional and realistic training and these projects are important in extending the College's collaboration with the local industry. The focus of this paper is the practical value obtained by student projects. The results of (successful) student projects in software engineering are working prototypes, or the first version of a system. However, few of the systems are integrated in the customer's everyday use. Indeed, too often the results of the projects are not used, or are used only for a short period. What can be done to extend the value and benefits for the industry after the students project period? Success and critical factors are described, and examples from projects are given. Some systems are still used 1-2 years after installation. First, the customer must spend more time to communicate with the students. They must give input and cooperate in the user requirement process, and evaluate and give feedback on prototypes and documents produced. The project period (for the main project) should always be one year. In the starting phase, the time is used to sample background information from the organization about their business. In the finishing phase it is important to use more time to test the system in the users' environment, and give user training. The user and system documentation must be complete and well structured. The next critical factor is software maintenance. The customer should have software engineers who have time to maintain the software. In the project period the software engineers should instruct the students so that they know the system and the system is developed according to the company standard. In some cases the students are hired or even employed by the customer. The main conclusion is that student's projects have a great potential for the industrial partners if these guidelines are followed.*

Index Terms ¾ Project based learning, college and industry collaboration, software projects.

INTRODUCTION

Project Based Learning was introduced at the faculty of engineering and economics at Tromsø University College in 1994. The purpose was to integrate project work in the education, and to make it a new pedagogic method. Project based learning will also make the students more responsible for their own learning process.

Our model described in [1], is built on experience from Aalborg University, Denmark, and the Telemark Model from Telemark College, Norway. The use of this model in engineering education is well documented by Clausen in [2]-[4]. Details from curriculum and examples presented in this paper are mostly from the computer technology study where I am a lecturer. First we give a short description of the model and our experiences with project based learning. Then the paper focuses on external projects and the value of the project result for the industry and the use of it after delivery. Too often the results of student projects ends up only as a report in the bookshelf!

The results in this paper are based on several years of experience as an adviser for several (more than 100) projects, the project reports, and (informal) interviews with students, colleagues and contact persons in the company or institutions we collaborate with. This methode is referred to as action research, and Tiller [5] has described how this methode can be used to document experience from teaching practice. He introduce action learning as a continuos learning and reflection process supported by colleagues where the intension is to get anything done! The methode includes collecting and using information and documetation in the organization and from your own (teaching) practice.

A database for collecting information of projects was finished in May this year (of cause a student project), so a more complete presentation of statistics will be available later. The database will contain information on project title, students, advisers, company, product status after delivery etc.

MODEL FOR PROJECT-BASED LEARNING

The Norwegian engineering education lasts for 3 years, each year is divided into 2 semesters and the semesters are numbered from 1 to 6. The courses are assigned credit points ("vekttall"). The normal workload for a student is 10 points pr. semester (From the start of the next semester we will use ECTS).

Projects are integrated in the curriculum. In the computer technology study projects comprise ca. 20 % of the students work in 4 semesters, 10 % in the fifth, and 50 % in the final semester. There are three categories of projects.

The first type, in the first semester, has as its goals to help the students to learn project management, teamwork and (as a "spin off") it helps the socialization process of new

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students. The group size is up to seven, and the advising process is more intensive and regular in this project than in later. This project is also used to train new teachers in project advicing. Topics for this project are general problems like ethics, environmental problems, natural resources, politics etc.

The second type is in connection with courses where the projects can replace traditional exercises, and will sometimes be referred to as "problem based learning".

The third type of project is realistic projects for external institutions or companies. For the computer technology students the projecs are in software engineering and main project.

Project evaluation is based on the project report, oral precentation and questioning, and demonstration of software or other products from the project. The first project is evaluated to pass/fail while the other are evaluated with individual degree.

Software Engineering

This course has an introductory part with lectures in software engineering theory, including different models for software engineering projects. Both traditional and object oriented methodes are covered. The projects are realistic software engineering project for external institutions or companies, and can be a complete development of a small system, or the first version or prototype of a larger system.

This project is both of the second type (it replaces exercises), and it is also a smooth transition to the third type because it is external. Group size is 2 to 5. The collection of information from the users and writing user requirement specification that is analyzed and translated to software requirements is an important part of the course. The students have to select project model (often prototyping or other incremental models are selected), and they have to estimate and manage time used on the different activities in the project. The project workload is 2 credit points.

Main Project

The main project is also external, and the goal is to make a new product or new software system. Now the main project starts in fifth semester with a workload of one credit point, and continue in the last semester with a workload of five credit points. In the fifth semester the time is used to define the project, get information from the external partner, and writing the first version of the requirement specification. In the last semester, the product is constructed, and/or the software system is implemented, and reports are written. For software product, installation and testing in the users environment, and user training are also part of complete projects.

Experiences with the model

Our experiences with this model [1] are mostly positive. The five projects give the students good experience in project work, planning and management. Report writing and oral presentation of project result improve significantly from the first project to the last, and they develop high quality and creativity in using tools for presentation. The exam results are usually better from project based learning courses than from traditional courses.

Project work gives a better studying environment. The students work more and more evenly in projects, and the project group collaborate in other courses too. The students take more responsibility for their own learning process, they have to define their own learning goals, and solve problems different form other courses. The project group gives new students a good start in building a social network.

The external projects give the computer technology students extensively experience in software engineering, most like it is done in the industry. Projects have also resulted in employment of students.

The teachers/advisers get contact with the industry, and the projects give new challenges and variation compared to traditional teaching.

We have of course problems with project based learning, like cooperation problems in the groups, students drop out, or are excluded from the group (they don't do their job), and sometimes a group split up and misses the project. The problems are solved at best in each case.

EXTERNAL PROJECTS

External projects are originated from companies contacting the college, or the teachers use their network of contacts and connect the student group to the "employer". Sometimes the students have contacts from working experience, friends or family members who have problems that are adequate for a project. (Every company has need for new software!) The college is working on establishing more formal cooperation contracts with companies in the region, and projects will be one of the issues.

Companies cooperated with are University of Tromsø, University Hospital of North Norway, including Norwegian Centre for Telemedicine, Andoya Rocet Range, Tromsø council, Kongsberg Spacetec AS, Tromsø Satellite Station AS, Sensotec AS, Norwegian Costal Voyage (TFDS) etc.

In the new quality reform for higher education in Norway [6], the governmental colleges are given special assignments to contribute to regional innovation, supporting development of industry and governmental administration. The Research Council of Norway and Norwegian Industrial and Regional Development Fund (SND) have programs to stimulate cooperation between colleges and industry, and to collaborate on reseach projects. They are also funding establishment of new industry. Tromsø University College participates in several programs, for instance FORNY [7] and SMB [8].

FORNY is designed to encourage students, researchers and research administrators to focus more attention on the potential commercialisation of research results. This could mean that the inventor of the idea and other rightsholders

could take part in a commercial success based on idea at hand. The program can help to seek legal protection of the idea, evaluate commercial potential and competitiv condition, and to set up a business plan. FORNY also supports a Norwegian network of technical colleges with the goal to include entrepreneurship in the engineering education, and to educate lecturers in this.

SMB (Small and Medium size industry, less than 100 employees) has several programs, among others "SMB competence" which has as its goal to extend the competence in the industry, and to support collaboration between college and industry. SMB also supports innovation projects where a member of the college staff is consultant and adviser.

When a project idea is proposed, and a project group is allocated to the "employer", the group describes the project and its goals in an initialization document that is approved by the college.

VALUES OF PROJECT FOR THE INDUSTRY

The greatest advantages for the company will of course be if the project results in a complete new product or software system. But even a prototype or a well-documented requirement specification will be of high value for the company. And one project in a company will often result in a new project in the next semester, either for the same group or a new one. The new project can be either the next activity of the former, a new subsystem that will be integrated in the former system, or a complete new system or product.

The students' work in projects is estimated to about 50 hours pr. credit point. For a project in software engineering (2 credit points) it is about 100 hours work for each student, and for a main project (6 credit points) it is 300 hours. For a group of four students the main project is 1200 hours, and often the groups work even more! Even if the students have lower productivity then a professional consultant, the price to be paid for a similar project would be high! Small companies have not capacity to run software projects, and cannot afford to pay consultant to develop new (tailored) software.

The workload for the total student group adds up to several man-labor years! The University College of Vestfold has in the FANG project [9] priced a student hour to 250 NOK (ca. 33 Euro), and a teacher consulting hour to 500 NOK (ca. 66 Euro). FANG is an example of a successful collaboration project between college and industry, and has resulted in new products or establishment of new industry.

A lot of projects develop typical application programs including a database, web presentation and even "web-shops" for small companies. The company will be able to maintain the information on the web pages, and will be independent of high-cost web designers and consultants.

There are several examples of (software) products that are used by the industry partner, and some are presented later. The value for the company or institution is new products, reduced manpower or improved business processes.

The ultimate value of a project would be if the students could start their own company based on the product, or that the product could be commercialized and sold by the company, or licensed to another company.

SUCCESS AND CRITICAL FACTORS

However, few of the systems are integrated in the customer's everyday use. Indeed, too often the results of the projects are not used, or are used only for a short period. What can be done to extend the value and benefits for the industry after the students project period? From my experience as a project adviser I have noticed several factors that are critical for project success, and use of the project result (product and/or software). For every project critical factors will include:

- The project goals must be well defined so that it is easy to verify that they are reached.
- The customer must spend (more) time to communicate with the students. They must give input and cooperate in the user requirement process, and evaluate and give feedback on prototypes and documents produced.
- The user requirements must be fulfilled.
- The programs must be user friendly, and have good user interface, preferably a Graphical User Interface (GUI).
- The documentation must be complete and well structured, both system documentation (for maintenance) and user guides, including online help function.
- The project period for the main project should always be one year, because in the starting phase, the time is used to sample background information from the organization about their business, and the students often have to wait for information or feedback from the company, and in the finishing phase it is important to use more time to test the system in the users' environment, and give user training.
- Maintenance and support must be done after the installation of the system, either by the staff in the company, or by the students. If the company have software engineers, they should instruct the students in the project period so they know the system, and ensure that the system is developed according to the company's standard (if they have one).
- General support from the management of the company to cooperate and use the software.
- And of course, hard working and skilled students with experience from project work.

For the college and the long term improvement of project work, industrial collaboration and establishing of new business and industry, there are other critical factors:

- Continuously improving the education in project work. In the quality reform of higher education in Norway [6], there are recommendations for improving quality of the education and studying condition. It also recommends more project work and more advising of the students.
- Improving the project process of the college and for each project.
- Include entrepreneurship, marketing and (more) economics in the engineering education. We have an optional course in entrepreneurship and business establishment (project based!) where the students can use their main project as case in commercialisation and business planning. Because it is a new course and of low interest from the students, the course have not been run yet.
- Actual projects should be considered for commercialisation, and a business plan should be made during the project period, so that funding of further work is ready when the project is delivered. Usually the students get jobs on different places, and it is difficult to continue the commercialisation process.
- Give information of the different funding possibilities for industrial developing projects and establishing of new industry, for instance SMB and FANG.

Using those guidlines will improve the value of students projects and the collaboration between college and industry.

EXAMPLES OF PROJECTS

In this section we give some examples of projects that have been of great value for the company or the institution. Some systems are still used 1-2 years after installation. I have selected two projects from 2000 (described in [1]), and two projects finished this year (2002).

Midnight Sun Marathon

Midnight Sun Marathon is arranged every year in June or July in Tromsø in the middle of the night, and hopefully in midnight sun! There are other distances too (half marathon, 10.000 meter etc.) The organization committee asked me in June 1999 if a student group could make a new software system for management of the competition. The old system was DOS-based and not prepared for "Y2K" (a well-known situation!).

Basic requirements for the new system: Multi-user, client-server Oracle data base system, the server running NT operating system and clients running Windows. The system will register all the participants in several classes and distances, generate start numbers, getting time information from the clock, making result reports, give the speaker information etc.

A group of five students started the project in the fifth semester in September 1999. They had to define several learning goals: Set up and run an Oracle database server on NT platform, learn to use development tools etc. The requirement specification based on input from the committee and tests of the old system were also written. The group got some help and instructions (on Oracle problems) from one of the sponsor companies (Telenor). The system was implemented in the sixth semester. It was tested under realistic conditions in March in a cross-country skiing race for children. After some modifications, the system was delivered in April 2000, and ran in the sponsor's environment where they registered the competitors. The system was used in the competition in July 2000.

In addition to the new system and documentation [10], the project had great learning value for the students, and one of them are employed by the sponsor. He maintained the system and added some new functions, and the system was used in the MSM competition both in 2001 and 2002. Other organizations have asked for the system, so it may have a commercial potential!

In addition to the general success criteria mentioned above, this project had special support from an adviser and control group from the sponsors' computer departments, and got help from the sponsor to solve technical problems.

Andoya Rocket Range

Andoya Rocket Range (ARR) is a permanent launch range for sounding rockets and scientific balloons. On the range there are instruments giving environment data supporting the rocket launching. Those include magnetometers (measuring the geomagnetic field) and riometers (Relative Ionospheric Opacity Meter measuring cosmic radio noise, which indicates the ion density of the atmosphere). The college had two projects in collaboration with ARR from 1998 to 2000. The first project [11] started in September 1998 and was finished in May 1999. Two students made a system to collect data in real time from the instruments, and store the data on an NT server. The system was developed in Visual C++, and installed in May 1999, and it was still running in December 2001.

The success depends among other factors that the system was tested in the users environment, and that ARR has software engineers who maintain the system. Because of upgrading of operating system, ARR now consider to reengineer and upgrade the system.

The next project for ARR, where a student group should developed (client) software for accessing and displaying data from the NT server, was not used after delivery.

University Hospital of North Norway

I will describe two of the projects finished this year (April 2002). Both are in collaboration with University Hospital of North Norway, and they had immediate value and were preceted in the local newspaper "Tromsø" [12].

The fist called "Svaltann" is in collaboration with Norwegian Centre for Telemedicine, a department of Hospital. One of the two students in the group is dentist, and she is now also an engineer of computer technology!

They made a system for transferring dental information from the dental clinic at Longyearbyen, Svalbard (an island at 78 degree north, 1.50 hours flight time from Tromsø) to the surgeon dentist in Tromsø who visits Lonyearbyen regularly. The system has a web-based user interfaces, and includes (digital) storing, displaying and transferring X-ray pictures.

In May the Norwegian Centre for Telemedicine announced a position with required education as dentist and engineer in computer technology and there is only one candidate for the job! The system will now be tested in the network of dental services in Norway.

The second project in collaboration with the University Hospital had immediate value for the technical department. A group of three automation students made a new control system for a washing machine for hospital beds used in surgical operations. The control system of the ten years old machine broke down a year ago, and the price for a new unit is ca. 1.2 M NOK, and the cost of repairing the machine would be ca. 300000 NOK. The students made a new control system using, and the machine is now washing again. The component cost was ca 42000 NOK. The control system is well documented, and the technical department has got the responsibility for further development and maintenance. The College is honoured by a donation of laboratory equipment for 40000 NOK from the Hospital.

CONCLUSION

Project based learning and external projects give the engineering students a better preparation for working life than (only) traditional education. External projects promotes the cooperation between the University College and the industry, and the project results have cosiderably value for the industry partners.

There are a great potential to improve the values of projects for the industrial partners by following the guidlines described as success and critical factors. Especially it is important to stimulate engineers to entrepreneurship. The Norwegian industy has conciderably demand for new products and new business, as the traditonal industry reduces the activity or move abroad.

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