Project Based Learning in Computer Science

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Abstract

Project based learning (PBL) has become a widely accepted method of teaching at the University of Applied Sciences – Technikum Wien. This paper describes how computer science students are integrated into the research programs and real life projects in companies or at the University. Faculty staff organizes the work of students, to minimize the risk of failure of the students. The benefits for the students are numerous; they learn to work in real life situations, gain practical knowledge in various fields and are able to enlarge their network of contacts to companies and universities.
In many cases students are also allowed to suggest their own projects. These projects can be projects for companies, or software projects students want to realize.
It is very interesting to compare these two types of practical experience. Both forms of projects do have their own challenges and advantages in teaching.
A detailed analysis of around 500 projects shows how difficult it is to assign marks to projects. In many cases projects suggested by students get lower marks than projects suggested by faculty. However students are highly motivated to work on their own projects and it seems they do learn more in such projects.

1. Introduction

Many different skills have to be acquired by students in computer science. To program computers to make them do what the programmer wants them to do, is one of the most difficult tasks. Very often questions like, “Please tell us the ten most important facts I need to know from C#” are heard by teachers. The response always is the same; there are no “ten most important points” in any computer language.
Learning a programing language is very similar to learning a real language. Grammar and usage of the language depends on the needs of the program. And theoretical knowledge without sufficient practice in using the programming language in real life situations is simply not enough to master the language.
Practicing a computer language can be done in many ways. Teacher very often try to provide an artificial environment where students have to solve specific tasks to practice specific elements of a language. A very different approach is to include real life projects into the curriculum to allow students to practice their knowledge. Both approaches do have their specific advantages and disadvantages.

2. The motivation to learn

Whenever one takes a closer look to the driving force of achieving a goal in life motivation turns out to be one of the key elements. The motivation to do something mainly comes from two sources. Intrinsic motivation is the motivation which comes from the individual himself and does not expect an external reward. Extrinsic motivation on the contrary is an outside force to make somebody do something [1-3]. In the case of practising a computer language or other skills, extrinsic motivation could be the expectation to pass an exam, whereas an intrinsic motivation could be the desire to be able to make a computer doing something the student wants it to do.
Motivation theory is complex; however in many cases extrinsic motivation tends to replace intrinsic motivation. In scenarios where this happens, the overall motivation to *really master* a subject in the long term is reduced. Obviously our university system largely relies on extrinsic mechanisms by forcing students to pass exams.

Let´s remember those days when we ourselves have been students. What motivated us to learn? In many cases it simply was the question “How can we pass an exam, by doing just the minimum amount of work”. This question is a very good one, because efficiency is one of the main goals of humans in real life. Unfortunately above question immediately leads to the question, “What is Professor Huber going to ask at the exam.” After careful investigation of the subject, in many cases it turns out to be more efficient to study the questions Professor Huber likes. In most cases this is easy, students tend to be a very well organized community and usually to have sufficient samples of exams to answer exactly this question.
One might argue, if Professor Huber carefully selects the questions, the questions will reflect exactly what students need to know from the subject. Unfortunately this is not true for computer languages. Exams which last a couple of hours are not suitable to test what skills students did develop in programming. In many cases only the result of projects are useful to judge how students actually solved the challenge of writing appropriate software.

3. Project based learning

In the curriculum of the bachelor program Computer Science, beginning from first semester Project Based Learning is implemented since more than ten years. Students have to work on projects in all six semesters of the bachelor program.

Semester	ECTS Credits	Workload in hours	Subject
1	3	75	Web developpement
2	3	75	Web dveloppement with respect to project management
3	4,5	112,5	Programming and project management
4	4,5	112,5	Agile and classical project management
5	6	150	Large software project
6	15	375	Internship (Company or University)

Table 1: project based learning in the bachelor program computer science

In the first and second semester the workload is 3 ETCS, in semester three and four this is increased to 4.5 ECTS, in the fifth semester already 6 ECTS are assigned to projects. Half of the sixth semester is formed by a large project. In many cases this project is carried out in companies. Some students chose a project offered by the faculty, such as COAST or similar projects in such cases the internship is carried out at the University.
Students usually work in teams of four to six members. Each team is supervised by a lecturer. The lecturer does not solve problems with arise, she only suggests possible solutions. However it is crucial in most cases that the lecturer does have profound knowledge of the content of the project and all involved programming techniques.
This structure of our way of project based learning is responsible for the relatively high cost of this form of teaching.

4. Where to the projects come from?

Where do the projects come from? This simple question turned out to be a major issue. In the first years of this form of teaching we “invented” Projects just for teaching purposes. We had to learn, this should be avoided for many reasons. The most important reason is, in such a case there is nobody who really is interested in the result of the work. This means no care has to be taken in specifying the project and nobody is there to finally judge if the result is useful or just another program.

Four different types of projects turned out to be very useful. These projects can be categorized into the following four categories numbered 1 to 4:

1. Projects brought by students themselves
2. Projects offered by the university.

Both types of projects can be further separated into projects which do have a real customer and projects which do not have a customer who needs the results.

a. Projects brought by students themselves
b. Projects for a company, the contact is brought in by students themselves.
c. Projects which students for their own use

Another source of nice projects is the need of the university.

3. Software for the needs of the faculty

The project is part of a research project of the faculty, or the project serves the needs of the faculty (e.g. software for organizational purposes). In some case the entire work except the organizational aspects are done by students.

4. Projects for a company.

The project in such a case was offered by the company to the university and students are involved partly. In some case the entire work except the organizational aspects are done by students.

5. Students who learn more get better marks?

Project results are difficult to judge. The “result” of the work from a teaching point of view usually has to be expressed in a final mark. The Austrian system of marks consists of five consecutive numerical values where “1” is the best mark, and “5” is the worst mark. Mean values are easy to obtain and statistics are relatively easy to calculate. Please note, that this statistical analysis only gives a first impression as it assumes that the distance between 1 and 2 is the same as between 2 and 3 and so on.

To be able to judge the result of a project deep knowledge of details of the project is required. In many projects students suggested it is very difficult for a teacher to get this knowledge. It is much easier to see if the students struggle and that expectations expressed in the beginning cannot be reached.

If the project was suggested by faculty for example, the situation is different. In such a case the teacher usually is involved in the definition of the project and is very interested in getting a product which can be used later on. It is not surprising, that there is much motivation and knowledge which helps students. Furthermore the teacher is usually experienced in managing projects and defines the goals of the project in a way it is likely they can be reached.

The authors compared the marks of students involved in these to types of projects. Projects have been divided into two groups.

Group A projects have been suggested by the students, group B projects have been suggested by faculty. The number of involved students are similar, group A consisted of 228 students, group B included 220 students. In both groups the final marks are very good. However the mean of group A is around 1.90 the mean of group B is around 1.64, a small but significant difference. A Mann-Whitney U-Test shows a high level of significance, $p < 0.001$.

This is not surprising, as the teacher in group B projects does have more knowledge and more interest in the product. However students in general prefer projects they suggest themselves. Although tis is difficult to prove, the question arises why these students tend to get lower marks?

Type of Project	**A (A1+A2)**	**B (B1+B2)**
Number of Students	226	220
	Mark	Mark
Mean*	1,90	1,64
Std. deviation of mean	0,07	0,07
Variance	1,09	1,18
Std. deviation	1,05	1,09
Minimum	1	1
Maximum	5	5
Median	2	1

* p < 0,001 (Mann-Whitney U-Test)

Table 2: Comparison of projects, details in text.

How do the marks reflect the result of the project? In Computer Science second year projects, approximately 60% of the result is based on the project itself, namely completion of the project, performance of the implementation, completeness of documentation and other important parameters which are used in Computer Science. Approximately 40% of the result is based on the organization of the project by the students themselves. This means 40% of the result is dependent on the management skills of the students.

The difference in both groups of projects comes from the experience that those persons have who suggested the project. In the case of students very often the lack of experience leads to project definitions which are very difficult to fulfill. Especially the estimation of effort is such a parameter. Only very experienced people are able to estimate this important parameter fairly correctly. Persons with less experience tend to underestimate the necessary effort to complete the project.

From this point of view it is obvious, that in case of a project suggested by faculty members the measurable result of the project tends to be better. But one has to keep in mind; this does not mean anything on the learning experience of students. From the continuous observation of the projects, the authors suggest, that the learning experience and the amount of learned skills and facts is better, if the students suggest the project themselves.

References

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