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Project Based Learning in Computer Science – A Review of More than 500 Projects

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Abstract

Project Based Learning (PjBL) has become a widely used method of teaching in technical subjects. In the last ten years our experiences with PjPL reveal a very complex picture. On the one hand PPL does have benefits, on the other hand the handling of numerous projects is complex and the evaluation of the results difficult to standardize. Teaching with projects quite often turned out to be chaotic in the perception of students. Remarks, based on the results of projects turned out to be highly depended on the subjective point of view of the teacher.

Most teachers agree that teaching with PjPL has numerous advantages especially in the field of computer science. Students are able to apply their technical knowledge, acquire practical skills in programming, get involved into team processes and understand in some cases even so called soft factors in project management. However IT projects in teaching environments behave very oddly when one tries apply standardized frameworks onto them. After more than ten years of routinely use of PjPL in Computer Science the authors try to identify critical success factors for such projects. Four main reasons could be identified:

1. Students are no experienced project managers and frequently run into problems in early phases of the projects.
2. The motivation of students to actually finish the project varies between low and extremely high values.
3. Interactions of teachers with students, dependent on factors like specific experience of a given teacher with a specific project or students who are shy to ask seemingly stupid questions very early.
4. Origin of the project or project idea.

Keywords: Project Based Learning, Computer Science, Motivation

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1. Introduction

Teachers at the UAS Technikum Wien apply a variety of teaching and learning methods to support the learning performance of the students. Traditional forms of teaching and knowledge transfer such as the traditional lectures were completed by more self-responsible and activating forms of learning. One of the main reasons is that students do not learn solely through listening but also through facing up and dealing with the learning contents. This fosters both the pleasure of learning and the transfer to the professional praxis. Additionally, it is to be said, that there is no best teaching method. Because of that a mixture of teaching methods can better take into account the particular framework conditions.

The selection of the respective teaching method considers the learning prerequisites of the students as well as the nature of the particular subject matter (e.g. factual knowledge, action knowledge) and the intended qualifications. Therefore there are a lot of different teaching methods such as

- traditional lectures
- projects, case studies and business games
- practises and laboratory work
- self-organised, esp. project based learning
- blended learning
- trainings and workshops with smaller groups
- diverse teaching techniques, e. g. buzz group, one-minute-paper
- group sessions moderated by the students themselves

Determined by the respective method teachers assume different teaching roles: Sometimes they consider themselves as coaches who accompany personally the individual learning paths of their students, sometimes as experts who consult in a more subject-specific way.

In general, self-organized learning denotes all those learning forms, in which students organise widely autonomously their learning processes. They can influence

- learning objectives and learning content
- learning styles and working steps
- organizational forms, learning partners and time budget
- ways and quantities of feedback and expert support

Dependent on the learning objectives, the timeframe and the particular learning prerequisites diverse open zones are available for the students. Sometimes it is reasonable for the teacher to specify the objective and the learning content; sometimes this can be handed over to the students. Self-organized learning processes are not without presuppositions. On one hand it requires a minimum of student competence to control and organize oneself, on the other hand it requires a teacher competence to give advice to the students.

Project based learning as one of the variants of self-organized learning focuses on a project that is a purpose of a temporary nature which enables the students to work experience based and mostly interdisciplinary on a concrete task. Moreover, the students can contribute their own abilities and wishes. Not least project based learning matches some important teaching principles:

- Situation relatedness: Contents are arranged according to concrete current or future situations.
- Action relatedness: Contents offer assistance and orientation for concrete actions.
- Science relatedness: Contents are oriented both by the level of knowledge as well as by the topics and methods of the respective scientific discipline.
- By examples: Contents were selected so that the wealth of knowledge is depicted by a few typical cases (which are representative for similar issues).

- Structure: Contents transport also structural knowledge such as basic ideas, elements of theories, models, schemes of explanations etc.

2. Project Based Learning in Computer Science

Project Based Learning (PjBL) has thus become a widely used method of teaching in many technical subjects. On the first glance, teaching with projects seems to be both, easy and desirable. However, over the last ten years our experiences with PjPL reveal a very complex picture. On the one hand PjPL does have benefits, on the other hand the handling of numerous projects is extremely complex and the evaluation of the results is very difficult to standardize. Teaching with projects quite often turned out to be chaotic in the perception of students. Remarks, based on the results of projects seem to be highly depended on the subjective point of view and background of the teacher.

Semester	ECTS Credits	Workload in hours	Remark
1	3	75	First experiences with IT projects.
2	3	75	Software development process
3	4,5	112,5	Standards and project management
4	4,5	112,5	Special issues of teamwork
5	6	150	Self-directed Learning
6	15	375	Internship (Company or University)

Table 1: project based learning in computer science (bachelor)

In the master program multimedia & software engineering PBL also plays an important role. A large project in the first semester is part of the curriculum. The master thesis is entirely carried out as a project in the second semester.

Semester	ECTS Credits	Workload in hours	Remark
1	5	125	Large software project
2	20	500	Master thesis (project)

Table 2: project based learning in multimedia & software engineering (master)

3. Difficulties with Problem Based Learning

Most teachers agree that teaching with PjPL has numerous advantages especially in the field of computer science. Students are able to apply their technical knowledge, acquire practical skills in programming, get involved into team processes and understand in some cases even so called soft factors in project management. However IT projects in teaching environments behave very oddly when one tries apply standardized frameworks onto them. After more than

ten years of routinely use of PjPL in Computer Science the authors try to identify critical success factors for such projects. Four main reasons could be identified:

1. Students are no experienced project managers and frequently run into problems in early phases of the projects. These unforeseen problems need time to be solved, time which cannot be used for the project itself.
2. The motivation of students to actually finish the project varies between low and extremely high values.
3. Interactions of teachers with students, dependent on factors like specific experience of a given teacher with a specific project or students who are shy to ask seemingly stupid questions very early.
4. Origin of the project or project idea.

One of the factors which seem to influence severely the subjective feelings of the students on the project turned out to be the origin of the project resp. the origin of project idea. Therefore the authors tried to identify differences between these two types of projects (Project idea (a) from the environment of the students; (b) targeted by the UAS).

4. Extraordinary Results with Problem Based Learning

If students suggest the projects, the motivation of the students is very high [2]. For many years at the University of Applied Sciences - Technikum Wien, a group of students is developing a complex system of robots playing soccer ("Vienna Cubes" see http://cubes.technikum-wien.at). The project is one of the most interesting PBL projects at the University. Students from many different degree programs are involved. The results of the project are exceptional. For three consecutive years the team reached the quarter finals in the F180 league in RoboCup (http://www.robocup.org), the world championship in robot soccer. This means the team is playing among the 8 best teams in the world.

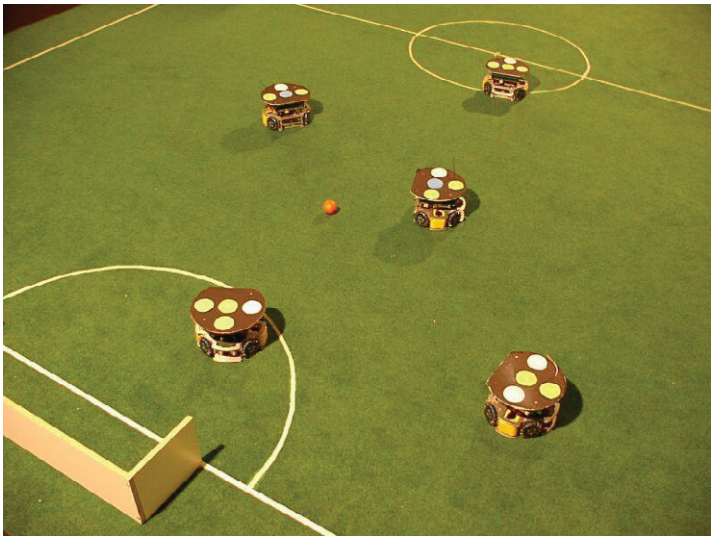

Fig 1: Students program robots to play soccer

5. Feedback on PjPL given by Students

After completion of the lessons students give feedback. The feedback itself is done anonymously and no data on the project the student was involved with is presently available to the teacher. However, a close look onto the feedback shows, that many students tend do state something like, "We do like the project lecture because we could develop our own software project".

Also, the feedback is anonymous and also not compulsory. Teachers cannot force students to fill-in the form. If students decide not to give any feedback nothing can be done. Depending on the mainly unknown reasons the rate of feedback varies from only 10% up to around 60% of all students. This and some talks to students give hints, that mostly feedback is given by students who either are very pleased with the PjPL lesson or are very unhappy with it. Very interesting is the fact that around 95% of the students seem to like the PjPL lessons a lot. Even more important for the teachers, almost all students state they learned a lot in the project.

6. Origin of the Project Idea

Many projects where the origin of the idea came from the students themselves turned out to be very successful. To get a closer look onto a statistical analysis of the remarks of projects with respect of the origin was performed. On the first glance one can assume, that students involved with projects originated from ideas from the students should have better marks than students involved in projects suggested by faculty.

Data of more than 500 projects are available at the present time. Out of these projects 132 projects involving 446 students of the 3rd and 4th semester in the course of computer science have been included into the study.

The selection of second year students has been done to assure a more homogeny pool of data. First year students have been excluded because many students, especially students of the 1st semester seem to be afraid of suggesting their own ideas. On the contrary students who already did project work in other environments are very much interested in their own ideas. However this second group of course differs from the first group, thus making statistical analysis very difficult. Third year students have been excluded because only in around 60% solid data was available on the origin of the projects.

7. Statistical analysis of formal project results

Statistical Analysis of the data is shown in table 3. Projects have been pooled into two groups. 226 students took part in projects where the idea or the project itself was suggested by the students themselves. Almost the same number of students, namely 220 took part in projects given by faculty. However, even this group of students could select from suggested projects. Therefore it can be assumed that almost all students took part in projects they liked. This is a very important fact concerning the question of motivation [3]. Only if students are driven mainly by intrinsic motivation, exceptional results can be expected. Moreover Spitzer states: “Human beings are motivated by nature” . He emphasizes the role of suitable learning tasks and amends: “Universities have in most subjects curricula that do not fit to the primarily very motivated students” [1].

Project idea originated from	**students**	**faculty**
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 3: Analysis of marks with respect to the origin of the project

The Austrian system of marks is based on five grades, a numerical “one” is the best grade, a numerical “five” is the worst grade. The calculated mean of the marks is 1.90 if students suggested the project and 1.64 in the case of projects provided by faculty. In both cases these results are very good. Somewhat surprising is the fact, that faculty projects have been judged better than projects suggested by students. This is not what the authors did expect. However one has to keep in mind that these results reflect the mark teachers give to students.

What do teachers judge? In the case of projects in Computer Science second year students 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. 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 huge difference in both groups of projects comes from the experience that those persons have who suggest the project. In the case of students very often the lack of experience leads to project definitions which are very difficult to fulfill afterwards. Especially the estimation of effort is such a parameter. Only very experienced people are able to estimate fairly correctly. Persons with less experience tend to underestimate the necessary effort to complete the project.

From this point of view it seems clear, that the results of a project suggested by students are good, but if the project is defined 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.

8. Conclusions

Project Based Learning in Computer Science is of high value for the students, but requires much attention in the organization. In many cases projects ideas suggested by the students turn out to yield exceptional good results. This is probably due to the high level of motivation students tend to have under such circumstances. Surprisingly these types of projects do not get as good remarks as projects defined by members of the faculty. Various facts could be the cause of this phenomenon. One likely cause is the complex organization of projects in Computer Science. If students suggest the idea, they also are in charge of defining project goals. But due to the lack of experience in defining such project goals these goals do have a tendency to be unreachable. The learning outcome in such situations is high, even if the results of the project in terms of marks are poor.

9. References

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