

Developing Soft Skills for Engineering: Experience with Student Team Projects

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While advanced technologies are entering schools at all levels, we claim that other skills required to deal with them in the complex modern world should not be neglected in the education system. In this article, a promising approach to interdisciplinary postgraduate education is described. The idea of the »Team project« course is to give the students the opportunity to gain experience in an extensive project where various skills are needed, e.g. teamwork, coordinating work, project management, research, problem solving, public presentations, time management, etc. The course is obligatory and held in the first year of the master study program at the School of Engineering and Management of the University of Nova Gorica. The main advantage of the course is to give the students hands-on experience of work on a project that is very close to reality. Students are forced to gain experience in teamwork and to overcome the uncertainties and obstacles that arise in such projects. Since the launch of the course, several improvements have been made with the aim of improving the performance of the course. Nevertheless, the course remains a challenge for both students and teachers.

Key words: teamwork, student project, engineering and management

1 Introduction

Solving problems in the complex modern world requires a lot of knowledge, creativity and collaboration. In the education system, the prevailing emphasis is on knowledge. To prepare students for the difficult challenges of tomorrow, just bringing more »ready-to-use« knowledge into the process might not be sufficient, because the amount of ever-changing specialized knowledge is too large. Therefore, it is important to teach students how to acquire newly developed and disseminated knowledge by themselves and equip them with knowledge technologies to support them in this process (Urbančič, 2007). It is also becoming imperative to bring the knowledge and creative potentials of individuals together through teamwork. The concept of network intelligence as the capability of going beyond a fixed individual identity through dialog, mutuality and trust (Palmer, 1998) is becoming more and more important. Consequently, the aspects of creativity and collaboration should also gain importance in education (Burns and Jordan, 2006). Therefore it is not surprising that training in communication, networking and team-work is explicitly listed among the necessary improvements suggested in the proposal of the European Commission on how to modernize Europe's universities (Europa Press Release, 2006).

In engineering study programs, the prevailing emphasis is of course on engineering knowledge and skills. Besides highly

specialized individuals, the industry and other employers also need professionals with the ability to connect the technological, economic and organizational aspects needed for the success of an enterprise. It is a big advantage for engineers to understand the connection between technical solutions and their economic aspects, and also to be prepared to work in interdisciplinary teams.

One of the study programs preparing students for this kind of job is Engineering and Management at the University of Nova Gorica. The lack of this profile may be indicated by the fact that the employability of graduates of this program within one year of graduation is over 96%.

Several good examples of introducing team-work projects into schools are known. Most early ones were from the United States, where some very successful forms of it have been developed - such as "d.school", originated at the Stanford Institute of Design (<http://www.stanford.edu/group/dschool>) and also introduced in Slovenia through the activities of Faculty of Economics at the University of Ljubljana. When designing team project work for students of engineering and management at the University of Nova Gorica, we were inspired by the team projects carried out at the International Space University (<http://www.isunet.edu>). The main elements of the course are learning by doing, combining knowledge from different backgrounds, fostering creativity and, most impor-

tantly, experiencing problem-solving and decision-making in an interdisciplinary team.

2 Methodology

The »Team project« course was launched in the 2006/2007 academic year. First the theme of the work was defined. The academic staff of the University of Nova Gorica was asked to make suggestions for the goals of the project. Of all the submitted suggestions, »Alternative uses of aluminium« was chosen as the project theme. The goals of the project were as follows:

- to propose new ways of using aluminium;
- to prepare a business plan for these new uses for potential investors;
- the presentation of the business plan to potential investors/users.

Twenty-four master students participated in the course. The participating students had various graduate backgrounds (4 engineering and 20 engineering and management). All of them were employed and had more than two years working experience on average. The course lasted for 18 weeks and the project was divided into 5 phases. The project plan is depicted in figure 1. In the first phase, an overview of aluminium production and usage was given. During this phase, a field trip was organized to an aluminium production plant and aluminium processing plant and an overview of the literature was presented to the students. This phase lasted 1 week. In the second phase, the students were divided into four groups. During that phase, each group conducted a study of

current state of the art in the field of aluminium use and prepared 3 ideas for alternative uses of aluminium in the future. This phase lasted 5 weeks and students had regular meetings once per week. They used different teamwork and problem solving techniques: brainstorming, weighted voting, Pareto analysis, etc. After the second phase, each group prepared a short presentation of 3 potential future uses for aluminium. The third phase lasted 2 weeks. During this phase all the participating students met twice. In the first meeting, each of the four groups from the second phase presented their 3 ideas for alternative future uses of aluminium. In the second meeting, 2 ideas were selected from the 12 presented for preparation into detailed business plans for potential investors. During the meeting, various decision making techniques were used, e.g. the definition of selection criteria, weighting the criteria and group voting. The fourth phase lasted 8 weeks. The purpose of this phase was the preparation of detailed business plans for the two selected ideas. During this phase, students were divided into 2 groups and each of the two groups was then further divided into 4 subgroups. Each of the 4 subgroups in each group prepared one section of the business plan: the market aspect, financial aspect, technological aspect and environmental aspect. At the beginning of the phase, four experts in the fields of marketing, business finance, materials and the environment gave the students an overview of their fields and guidelines for preparing the respective sections of the business plan. During this whole phase, the students had opportunity to consult these experts. In the fifth phase, the two groups prepared a final business plan and presentation for potential investors. The presentations were given to invited faculty staff.

Phase	Duration (weeks)	Groups and description of work				Output and comments
1	1	An overview of aluminium production and use, field trip to an aluminium production plant and aluminium processing plant				Output: a general knowledge of aluminium use as basis for further work
2	5	Group I.1: research and preparation of 3 ideas for alternative uses for aluminium in the future	Group I.2: research and preparation of 3 ideas for alternative uses for aluminium in the future	Group II.1: research and preparation of 3 ideas for alternative uses for aluminium in the future	Group II.2: research and preparation of 3 ideas for alternative uses for aluminium in the future	Output: 12 ideas for alternative uses for aluminium
3	2	Group I: Selection of one idea for the preparation of business		Group II: Selection of one idea for the preparation of business		Output: 2 ideas for alternative uses for aluminium
4	8	Group I.3: environmental aspect	Group I.4: technological aspect	Group II.3: Environmental aspect	Group II.4: technological aspect	Output: 2 business plans for alternative uses for aluminium
		Group I.5: market aspect	Group I.6: financial aspect	Group II.5: market aspect	Group II.6: financial aspect	
5	2	Groups I and II: preparation of final reports and presentation to potential investors				Output: 2 presentations of the business plans for potential investors

Figure 1: Project plan of the »Team project« course in the 2006/2007 academic year

The »Team project« course was conducted a second time in the 2007/2008 academic year. In this course, 17 postgraduate students participated (of these, 10 students finished engineering graduate schools and 7 finished engineering and management graduate schools). In this generation as well, most of the students already had at least two years of working experience. A business plan for the usage of a water source near Ajdovščina (Slovenia) was chosen as the theme for the project. The course lasted 8 weeks. Students were divided into 3 groups. Each group worked on the preparation of one aspect of the business plan: marketing, technology and finance. During the course, the students had 10 scheduled meetings. The project plan is presented in Figure 2. In the course, four tutors/consultants were available to the students: one industry expert with problem solving and project management skills, one industry expert in marketing, one industry expert in project management and finance, and one industry expert in the field of water treatment and water filling technology. During the course, the experts each held an introductory lecture in their field of expertise. In addition to that, students were given one lecture on final report preparation and public presentation. During the teamwork, the teams had the opportunity to consult each expert three times (see Figure 2). In the last session, the business plan was presented to a broad audience consisting of university staff, participating experts and invited potential investors. The students also prepared an official final report with a detailed business plan, which is available in the university library (Bizjak et al., 2008).

3 Results

In the 2006/2007 academic year, the students prepared two business plans for various alternative ways of using aluminium. The first idea was a do-it-yourself glass pavilion, which would have the following characteristics: light weight, low cost, flexible, expandable and ready for self-assembly (Stokelj et al., 2007). The second idea was a light and flexible greenhouse with the following characteristics: light weight, flexibility, modularity and multi functionality, also including a watering function, which brings additional added value for the user because no additional watering system is needed (Boškin et al., 2007).

In the 2007/2008 academic year, the students prepared one business plan for the idea of water filling at the Source Skuk near Ajdovščina (Slovenia). The main idea of the business plan was to create some extra value for the bottled spring water. It is known that there is fierce competition in the bottled water market segment. Therefore the students created an innovative idea for a brand called »Fortuna«, addressing the human desire for good luck and aiming to attract people looking for this at specific places, including casinos.

After the course, students were asked to fill in a feedback questionnaire. The main positive comments were related to the work in teams, the informal communication and socialization with their colleagues and the final presentation of the business plans.

The students' main complaints were related to the themes of the project (the students would like to choose their own the-

Session	Weeks lapsed	Description of work	Experts present
1	0	Introductory lecture: team work, problem solving, presentation of the theme, instructions for work, definition of groups	Problem solving
2	1	Introductory lecture: project management, business plan	Project mngt and finance
3	2	Introductory lecture: water filling technology; teamwork	Water filling technology, problem solving
4	2	Introductory: lecture marketing plan; teamwork	Marketing, problem solving
5	3	Teamwork	Project mngt, problem solving
6	4	Teamwork	Problem solving
7	5	Introductory lecture: public presentation; teamwork	Presentation, problem solving
8	6	Introductory lecture: report writing; teamwork	Problem solving
9	7	Teamwork	All
10	8	Final presentation	All

Figure 2: The project plan of the »Team project« course in the 2007/2008 academic year

mes for the project work), the management of the project (the students would like the project to be managed by the professor and not by one of them, or at least the organizational structure of the project should be arranged by the professor), scheduling (the students would like to locate the course in the second year of study, where the atmosphere would be more relaxed due to the better social relationships among the students) and the lack of analysis of the problems and experiences accumulated during the project.

4 Discussion

The idea of the »Team project« course was well accepted by both students and teachers. From the experiences so far, we can conclude that the course achieved its main aim – exposing the students to work on complex projects. The students that passed the course gained useful experience in research work, interdisciplinary teamwork, project management, problem solving, the presentation of business plans, and other »soft skills« needed in such projects. Even the students' complaints mentioned above actually indicated that the course succeeded in providing a simulation of a real situation, including typical problems with meeting dead-lines, taking personal responsibilities towards the team, learning about completely new things and looking for solutions without being told directly how to do it. It is important for students to have this training in a sufficiently complex, interdisciplinary and »almost real« but still controlled and safe situation.

During the courses, the teachers also gained precious experience of interdisciplinary work with students. The main lessons learned could be summarized as follows.

- The crucial elements of the project should be well defined at the beginning of the course, especially the goals, time frame, phases, goals for each phase and milestones.
- In the first execution of the course, the theme was rather difficult to understand for most of the students. While this offers an opportunity for students to develop skills in grasping new technologies, themes and problems, it might require too much effort, considering that the available time is rather limited. If the main goal is to develop teamwork and project management skills, the theme of the project should not be too complicated.
- The structure of the project should be as simple and logical as possible. In the first execution of the course, we planned too many phases and too many group reforms.
- Regular meetings should be scheduled during the course. Extended periods between meetings dilute the effort.
- Not too many other obligations should be planned for the students during the team project. In the first execution of the course, the students had two other courses running parallel to this one, which distracted their focus.
- The length of the course should be no longer than 10 weeks. This enables the right focus of the students and is close to the usual time frames of mid-complexity projects in the real business world.
- In some engineering studies, not much emphasis is placed on presentation skills. Therefore, instructions and guidelines on the preparation of final reports and presentations should be provided.
- Students were not very active in seeking help from the external experts provided, although this could be very useful. The role of the experts should be promoted.
- Students like using easy-to-use templates, such as templates for project plans, reports, minutes of meetings and other deliverables, which are created during the execution of the project. The use of templates leaves more time to spend on other, more important tasks and objectives.
- It is important that students are well informed about the objectives of the course in advance. It is also crucial that there is some time scheduled for discussions and analysis of problems, experiences and the lessons learned, which should also be summarized in a final discussion after the final report is given.
- Students prefer to be given specific instructions and want the team to be managed by the teacher. However, too much instruction and external control contradicts one of the important objectives of the course, which is the development of self-organization skills, personal initiative and responsibility. We believe that finding an appropriate balance in this respect is crucial for the success of the course.

In general, we can conclude that the »Team project« course brings added value to the study program by developing several important skills that cannot be obtained through the usual »Ex cathedra« learning style. In the future, some additional refinements to the course will be implemented in order to make it even more effective. However, no matter how successful such single courses at the university level might be, we strongly believe that the development of the skills needed for teamwork and for »open« problem solving without direct instruction or recipes should be supported throughout education at all levels.

References

- Burns, A.B. & Jordan, T.M. (2006). Learning to see the (w)holes, *Industry & Higher Education*, 2006 (February): 15-18.
- Bizjak, R., et al. (2008). *Srečna voda iz izvira Skuk: zaključno poročilo v okviru predmeta Projekt 1 [Lucky water from the Skuk source: final report of the "Team project" subject]*, University of Nova Gorica.
- Boškin, A., et al. (2007). *Rastlinjak z namakanjem: zaključno poročilo v okviru predmeta Projekt 1 [Greenhouse with watering function: final report of the "Team project" subject]*, University of Nova Gorica.
- Europa Press Release (2006). Europe's universities must be modernised, says Commission, *Industry & Higher Education*, 2006 (June): 148.
- International Space University, Team projects. Available from http://www.isunet.edu/index.php?option=com_content&task=view&id=152&Itemid=288 (June 2009).
- Palmer, J. (1997). The Human Organization, *Journal of Knowledge Management*, 1(4): 294-307, DOI: 10.1108/EUM000000004601.
- Stanford Institute of Design, d.school. Available from: <http://www.stanford.edu/group/dschool> (June 2009).

Štokelj, M., et al. (2007). *Zimski vrt MiXy: zaključno poročilo v okviru predmeta Projekt 1 [Glass pavilion MiXy: final report of the "Team project" subject]*, University of Nova Gorica.

Urbančič, T. (2007). From Fragments of Knowledge Towards a Bigger Picture: How Can the Process be Supported, *Organizacija*, 40(6): 263-266.

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Razvijanje mehkih znanj na tehničnih fakultetah: izkušnje s študentskim delom na projektih

Medtem ko si sodobne tehnologije počasi utirajo pot v izobraževalne programe na vseh nivojih, ne smemo pozabiti tudi na razvijanje sposobnosti za uspešno uporabo teh tehnologij za reševanje kompleksnih problemov v sodobnem svetu. Članek predstavlja obetaven način pridobivanja kompetenc za delo v interdisciplinarnih projektnih skupinah. V predmetu »Skupinski projekt« na bolonjskem magistrskem programu Gospodarski inženiring študentje pridobivajo izkušnje in razvijajo sposobnosti timskega dela, koordiniranja, projektnega vodenja, raziskovanja, reševanja konkretnih problemov, predstavitev rezultatov javnosti in upravljanja s časom. Predmet je na programu v prvem letniku kot obvezna sestavina študijskega programa. Študentom nudi konkretno izkušnjo projektnega dela, podobnega tistemu v realnih poslovnih okoljih. Preizkusijo se v interdisciplinarnem timskem delu, pri čemer morajo premagovati negotovosti in težave, ki se pojavljajo pri tovrstnih projektih. Po prvih izvedbah se je nabralo že več izkušenj, s pomočjo katerih izboljšujemo izvajanje predmeta. Kljub temu še vedno predstavlja precejšen izziv tako za študente kot za profesorje.

Ključne besede: skupinsko delo, študentski projekt, gospodarski inženiring