

Project led education in engineering courses: competencies to include

Natascha van Hattum-Janssen
University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal
natascha@eng.uminho.pt

Rosa Maria Vasconcelos¹

Abstract - As a result of the implementation of the Bologna Declaration and the growing emphasis on lifelong learning in a knowledge society, project education has been implemented in a number of engineering courses at the University of Minho. The degree to which the project is influencing the curriculum varies from course to course. In some course, the project is a project exercise in which already acquired knowledge is applied, in others, the project is the leading element of the semester and other subjects depend entirely on the project. In each case, the project has to be designed in such a way that all or most subjects of the semester are to some extent represented in the project. The competencies as developed for the project have to meet several requirements. In the first place, they have to be based in the subjects or content areas that form the project. They also have to fit within the general framework of the course and general project specifications of a particular semester. Apart from these demands, each project has to meet a number of specific requirements, related to the problem to be solved during the project: the solution needs to "work". Finally, the competencies defined in project education need to represent a number of soft skills. The article explores three student guides and the kind of competencies involved in three different project learning experiences.

Index Terms – Project-based learning, competencies, soft-skills.

INTRODUCTION

Because of the demands of the Bologna Declaration, which is, among other aspects, focussed on lifelong learning in a knowledge society, students at the University of Minho started to work in projects, as described in Powell and Weenk [1]. Project-Led Education (PLE) is replacing traditional teacher-centred education partly or entirely in a number of technical courses. Morgan, cited in Helle [2] described three general models of project work in education. The project exercise is the first one, aimed at applying knowledge and techniques already acquired in a familiar context. This kind of project work usually takes place within a subject. The second model is the project-component model

in which the project is more interdisciplinary and related to real world issues. This kind of project work is normally in parallel with other subjects. The third kind of project work replaces the traditional subjects by a complete project approach to the course as a whole. Projects are the basis of the curriculum and the learning goals are reached through a number of projects. Most of the projects that take place at the courses of the University of Minho use a project component approach, whereas one course substituted a traditional five or six subject semester almost completely by one project.

The main characteristics of the project approach are a focus on student-centred learning as opposed to teacher-centred learning. Students work in teams on open-ended real and existing problems and share the responsibilities for the process and the outcomes of the project. Teamwork is regarded as a way to construct knowledge. During this teamwork, students develop a sense of creativity and taking initiative. They develop critical thinking skills and communication skills. The content of the project is not related to one specific curricular area, but is interdisciplinary, reflecting the problems that students will face after their graduation.

COMPETENCIES AND SKILLS

In each project, students develop different kinds of skills and competencies. Competencies are broader than skills in a sense that they include an inseparable set of skills as well as knowledge and behaviour aimed at a specific result in certain circumstances [3]. Competencies are contextualised and placed in a professional context. To develop competencies, processes of learning and development are necessary. Competencies are usually interrelated. In project-led education, three types of competencies can be distinguished: general technical competencies that are often related to a specific subject, project-related technical competencies and non-technical competencies [4]. The general technical competencies are related to various disciplinary areas and are rather constant from one year to the next. They represent the technical competencies as described in the curriculum of the course. The more specific technical competencies are associated with one specific project and have to do with the topics that students are supposed to work on. In each project, students work on a theme, a problem and a solution and they

¹ Rosa Maria Vasconcelos, University of Minho, rosa@det.uminho.pt

are supposed to find a working solution for the specific problem. The demands of the particular problems create learning opportunities related to specific technical competencies. The non-technical competencies are also called transferable competencies or soft skills. These are developed during the project work, partly because of the group dimension and partly because of the nature of project work and its assessment. Team work implies communication between team members and processes of implicit or explicit leadership and management. Agreements need to be made and students need to experience how they deal with these agreements. Formal and less formal group processes provide learning experiences that support the development of certain transferable competencies. The project work itself and the related assessment processes also provide specific opportunities. Writing reports, giving presentations, using information systems and operating in close contact with companies are examples of learning experiences that are more typical for project work than for traditional classroom exam-based education.

The information on what competencies are developed during a project is usually stated in a student guide or a similar document provided to the students at the beginning of the project. This article describes three different cases of project-led education at the University of Minho and the

THREE PROJECT-BASED COURSES

Most of the courses that are of the responsibility of the Council of Engineering Courses include project work in a certain way. The type of project work varies from one course to another. Three courses are included in a case study on competencies in project work: Production Engineering and Management, Mechanical Engineering and Fashion Design and Marketing. All of these have a strong project component in the first year. In the first course, the project work can be regarded as project orientation, in which the subjects are replaced by project work. The whole semester is oriented towards one specific project. In the second and the third course, the project work can be characterised as a project component approach. In parallel with a number of other subjects in the semester, the courses introduced an interdisciplinary subject at the time of the Bologna curricular reforms.

At the Fashion Design and Marketing Course, the project subject is an increasing part of the semester. At the beginning of the semester, students start preparing the project for about two hours per week. At the end of the semester they need nearly their entire weekly time for the project. The tutors are the teachers of the other subjects of the semester. It is an 8 ECTS subject.

At Mechanical Engineering, the project is considered a subject like the other subjects of the semester in which application of knowledge and skills of the other subjects takes place and some new contents are developed. The subject counts 5 ECTS.

At Production Engineering and Management, four out of five subjects transformed into one broad project. The fifth subject of the first semester did not participate this one time for organizational reasons. The four subjects together count

for 24 ECTS. In this case, the project can be described as a project orientation. One broad, open-ended project with close links to the professional reality of a graduated student, reflecting an integration of different curricular areas is the foundation of the semester [5, 6].

QUESTIONS

Each of the projects provided support documentation to the students. These so-called student guides describe the goals of the project and a number of theoretical and practical aspects. As these guides provide fundamental information to the students concerning what is expected from them and as they are also the most important source of information about different competencies that are to be developed, they were analysed with regard to the following aspects:

- What competencies, skills, goals, learning results or other outcomes oriented information is given?
- What methods are described to accomplish the outcomes?
- What assessment methods are defined for which outcomes?

The information of the student guide is the main source of information as provided to the students and is taken as the only source for the purpose of this case study, although additional information may be provided in training sessions and separate documents in some cases.

INFORMATION IN THE STUDENT GUIDES

The analysis of the student guides of the three different projects showed a variety of information provided to the students. All guides provide outcome related information and refer to technical as well as non-technical competencies.

The guide for the Mechanical Engineering project identifies three types of competencies: specific competencies, transferable competencies and additional competencies. The specific competencies are e.g. the identification, basic characterisation and practical understanding of types and movements and mechanism and forms of fixations and transmissions of movement. The transferable competencies are competencies like project management, group work, written and oral communication and the development of foreign languages. The additional competencies are describes as actual research themes at mechanical engineering and the scope of the mechanical engineering industry.

The guide for the Fashion Design and Marketing course describes competencies for three different curricular areas that are involved in the project: Design, culture and society, Textile and Clothing Business and Group work supporting information technology. Apart from the competencies as identified for these three areas, a number of transferable competencies are described, divided in five groups: project management, personal and interpersonal skills, group work, communication skills and time management.

The Production Engineering and Management project guide describes the competencies for each subject involved in detail. Because the separate subjects are replaced by an extensive project, all outcomes related information of

subjects needs to be described within the context of the project. Each subject provides between three to seven specific technical competencies. Apart from these technical ones, the guide provides a number of transferable skills similar to the groups as defined in the Fashion Design and Marketing student guide. In the latter, the importance of transferable skills and the developmental opportunities for this kind of competencies in Project-Led Education is explained to the students.

None of the guides give explicit information on how to develop the specific competencies as described. They do however describe to some extent how Project-Led Education functions. The Fashion Design and Marketing guide uses about seven pages to explain students how to work in a team and what rules apply to this kind of intensive teamwork. Procedures, documents, roles of students and rules during group work are extensively discussed in the guide. The Mechanical Engineering guide dedicates a page and a half on the organisation of the groups, the stability of the groups and the coordination of the work and describes in the latter section rules and regulations with regard to responsibilities of groups, tutors and teachers and the procedures for handing in reports. The Production Engineering and Management guide, as referred above, pays attention to the importance of transferable skills, but does not describe the PLE working method in detail in the guide. Students however do participate in a training session on group work.

The assessment schemes for the three projects are rather different. The Fashion Design and Marketing guide describes continuous assessment, self and peer assessment and final assessment. The final grade is a weighted mean of all of these elements.

The Mechanical Engineering guide gives a final grade formula that is a weighted mean of the first oral presentation, the mid-semester presentation, the preliminary report, the final presentation and the final report.

The Production Engineering and Management guide shows a detailed scheme in which the weight of the project and the individual subjects are given. A correction factor for each student, a final project test, a prototype, the final presentation and the final report are included as well. The Fashion Design and Marketing course and the Production Engineering and Management course are characterised by and active participation of students in the assessment process. Students assess their own performance, the way their group is working and the performance of their colleagues. Process related aspects are in general not assessed by teachers, but by the students themselves as they are able to reflect on the processes they are involved in.

ANALYSIS OF THE STUDENT GUIDES

The three student guides do all contain information on expected learning outcomes, the project method and the assessment of learning. A closer look at the information however reveals a number of difficulties on a number of different aspects. Firstly the competencies as described in the guides. Most of them can be regarded as learning outcomes or learning goals, but not as competencies that share the characteristics as described above. The project setting will

most likely accomplish a close link to the professional practice, will most likely emphasise relationships between different skills, knowledge and attitudes, provides a context of learning experiences that enable students to develop competencies and provides a professional atmosphere in which student work, but many of the results are defined as rather straightforward learning goals that do not reflect an integrated set of knowledge skills and attitudes.

The division between technical and non-technical competencies and between general and more project related competencies is useful to students and is made to some extent in all of the guides. It shows to the students that PLE is focussed on a number of different competencies and highlights the importance of transferable competencies that can be regarded as the added value of PLE.

Each of the three student guides describes to some extent how students are assessed. They do, however, not give clear criteria for the different assessment moment. To the students it is clear what kind of assessment they will have to undergo during the project, but exactly how and what competencies are assessed at which assessment moment is impossible to deduct from the information in the student guides. In PLE, assessment is supposed to be integrated and assessment moment should be designed as such to avoid fragmentation. Presentations, prototypes, reports and tests can all serve as instruments to assess students. At the moment it is not very clear how the development of technical competencies is measured. The development of transferable skills is even more complicated. These are usually poorly formulated, because the teaching staff is not familiar with this kind of material and do not feel at ease assessing soft skills of students, although they all agree on the usefulness of these competencies for their students. None of the student guides pays explicit attention to the assessment of transferable competencies.

The integrated approach of assessment makes it rather likely that students are assessed with regard to the development of some of the transferable competencies. The written and oral communications that students have to prepare forces them to develop writing and presentation skills for example. The grades for these types of assessment may implicitly assess not only technical, but also non-technical competencies. Group work on the other hand provides excellent opportunities for leadership and management skills, but is, apart from some occasions in which peer and self assessment takes place not assessed in a systematic way. The assessment schemes as given in the student guides do not yet describe a balanced plan for assessment of all competencies in an explicit way. They do however describe responsibilities of teachers as well as students in the assessment process and recognise the importance of students as assessors of learning, especially concerning non-technical competencies.

DISCUSSION OF RESULTS

The guides that students receive when taking part in PLE experiences provide useful information to students on what is expected from them and how students are supposed to work. They also inform students on how they are going to be

assessed during the project and at the end of the project. Looking at the importance of technical and non-technical competencies in PLE, a number of improvements can be made to benefit even more from the advantages of project-led education. The definition of competencies in the first place, needs some special attention. Competencies that are balanced, related to the future professional context of the students and consist in a set of knowledge skills, attitudes and beliefs, combined with some indicators for good performance can help students to understand better what they are supposed to develop.

Explicit attention for group work and the processes of PLE as described in the Fashion Design and Marketing guide would be useful in all guides.

An assessment plan including the assessment of technical as well as transferable skills will help students of project-led learning experiences to work on the development of competencies in a more focussed way. As students are highly motivated by assessment [7], a good assessment plan will stimulate them to be more concentrated on what is considered important. The development of transferable competencies is a special case, because up until now they have not been included explicitly in assessment plan and if they are part of a project, they need to be part of assessment as well. As transferable competencies need to be assessed within a context, an integrated assessment plan for all competencies is necessary.

In general, PLE can be regarded as a useful way to develop technical and non-technical competencies, as also stated by Drummond *et al.* [8], who argue that developing competencies in a context that is similar to the context in which they will be used, is more beneficial than developing them in separate modules or in a traditional classroom setting.

ACKNOWLEDGMENT

This work was supported by the FCT under grant nº SFRH/BPD/18754/2004.

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