

# Project-Based Learning

## – Designing a Learning Cycle

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### Abstract

This paper describes four steps in designing a learning cycle for students in a project-based course. The steps are: (1) interactive lectures, (2) workshops, (3) guiding the project team and (4) learning assessments. These steps support teachers' teaching techniques. Project-based learning has been applied to undergraduate courses at Linköping University. Experiences from these courses are discussed and analysed in the paper.

**Keywords:** Course design, information systems education, learning, learning cycle, project, student-centred education.

### 1. INTRODUCTION

The use of project work is growing, and more and more people are working on projects (Project Management Institute, 2004). It is therefore important for students to learn about the project as a working method. General research has been done on factors for project success (Standish Group, 1995), and there has also been some research specifically about project-based learning (Grunnefeld and Silén, 2000; Melin, Axelsson, Wedlund, 2006; Melin and Cronholm, 2004; Wedlund, 2005; Wedlund, Axelsson, Melin, 2006; Weenk and Powell, 2003).

The purpose of this paper is to describe micro- and macro-level teacher activities related to designing a learning cycle in a project-based course. In this paper "teacher" refers to a person who has the overall responsibility for the course; a teacher may be an individual course leader, a team of instructors, or an examiner, depending on the type of university course.

The research approach is qualitatively grounded (Strauss and Corbin, 1990) in theory and in two years of practice in a prototype course called the Systems Development Project at Linköping University in Sweden. The context for this paper is a development project at the Department of Computer and Information Science, Linköping University. The title of the project is "Establishing Project-Oriented Student Work – Emphasizing Assessment, Examination and Feedback".

Results in this paper come from the Systems Development Project mentioned above. It is a fifteen-week undergraduate course. This course was redesigned for project work in 2002, and it was implemented and tested in early 2003. After that the course was evaluated and

redesigned. It was evaluated by students and teachers and compared with other pedagogical techniques. In early 2004 the course was implemented and tested again, and again it was evaluated and redesigned. Approximately ninety students have read the course. The course was evaluated by students and teachers, who focused their evaluations on pedagogical techniques, such as problem-based learning (Silén, 2001). The students' evaluations were both qualitative and quantitative. The evaluations were made at the beginning, middle, and end of the course. This paper includes topics that are relevant to other university teachers who give courses that include projects for students.

The paper is arranged in the following sections: section 2 describes how to develop a course for project-based learning; section 3 describes how to design a learning cycle in a course for project-based learning; section 4 contains the concluding discussion; and, finally, section 5 presents prospects for future research and limitations.

## **2. DEVELOPING A COURSE FOR PROJECT-BASED LEARNING**

This section describes learning strategies to be used by teachers in project-based courses, knowledge areas in project-based courses and, finally, macro-level and micro-level work in course development (see Figure 1 on the next page).

The teacher can use the learning strategies, which focus on principles of student learning, to plan *how* the students will learn. The knowledge areas can be used in planning *what* students will learn in a project-based course. Switching focus between the macro and micro course levels helps the teacher know when to do work for developing a project-based course and where and why the students will learn during the course.

Defining the learning outcomes for a project-based course is at the heart of the course development process. Learning outcomes are statements of what a learner (student) is expected to know, understand and/or be able to demonstrate after a completion of a process of learning (European Commission, 2004).

The teacher has to map the wanted course learning outcomes to the learning domains. The learning domains are based on the cognitive domain levels in Bloom's taxonomy (Bloom et al., 1956). In the cognitive domain, based on intellectual skills, the learning strategies for level 6, Evaluation, and level 5, Synthesis, are the goals. Action verbs such as *evaluate*, *create*, *design*, *invent* and *develop* are in focus. Thiagarajan's (2003) seven laws of adult learning are also used by the teacher in developing learning strategies. Adult students learn best when participating in processing information, and they also learn through trial and error.

The knowledge areas for a teacher (Wedlund, Axelsson, Melin, 2006) in a project-based course are the individual student's learning process, the project team's process and the project process. The individual student's learning process is the first process in project-oriented education. Kolb (1974) created his model, inspired by the work of Lewin (1951), out of four elements; Concrete experience, Observation and reflection, Forming abstract concepts and, finally, Testing in new situations.

The project team process is the second process used when teaching a project-based course. Tuckman (1965) described the four stages of project team (group) development. He recognised the distinct phases the group (students in this case) goes through, and suggested that a group needs to experience all four stages before it achieves maximum effectiveness. The project process is the third process in project-oriented education. It is based on parts of the Project Management Institute's areas of expertise needed by a project team (Project Management Institute, 2004). In this case the teacher corresponds to the project team. The parts to understand are the project environment (in other words the reality), project management knowledge, and application area. Application areas are usually defined in terms of technical elements, such as software development, pharmaceuticals, water and sanitation engineering, or construction engineering. General management areas are not included in this paper and study.

The preparation phase for a project-based course consists of macro-level course activities managed by the teacher. During this phase general knowledge about project-based courses is

collected. Next comes the planning phase, where the project-based course is planned in detail. It is followed by the accomplishing phase and, finally, by the evaluation phase. Teachers use micro-level course activities to teach specific sections of a course during the accomplishing phase. Examples include presenting interactive lectures, running workshops, guiding the project team and providing learning assessments.

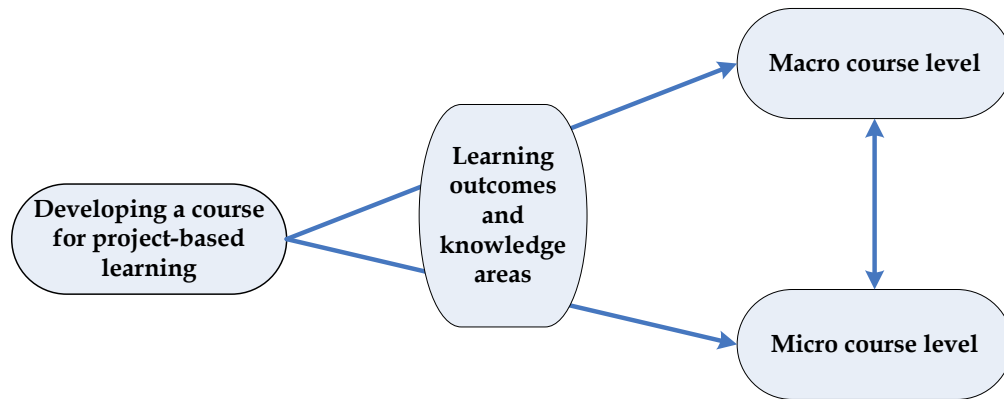


Figure 1. Switching focus areas between the macro and micro levels when developing a course for project-based learning

### 3. DESIGNING A LEARNING CYCLE IN A COURSE FOR PROJECT-BASED LEARNING

This section describes a learning cycle in a course for project-based learning (see Figure 2 on the next page). The steps in the learning cycle are interactive lectures, workshops, guiding the project team and learning assessments. Students move through the learning cycle according to the milestones in the project. The Systems Development Project course entails three rotations through the cycle.

Interactive lectures improve the students' learning. For instance, it can be helpful to use a computer (Bernhard, 1997) during interactive lectures to present and demonstrate the product of the project. Interactive lectures also facilitate two-way communications with the students, which motivates the students. The students will have to ask themselves and the teacher questions such as What will the project achieve?; When will it be completed?; Why is it important to complete the project?; Who will be involved?; Where will it take place?; and, finally, How are the project team going to do it? It is therefore important, in the first interactive lectures, to demonstrate the desired end-result of the project which students will work towards throughout the course. When the learning cycle has been completed once, the teacher begins the next cycle by focusing on another developing part in the product.

The use of workshops allows the students to build new information on existing knowledge. A workshop is separated into three different parts, and normally takes at least half a day to complete. The first part of the workshop is the framing part, where the teacher introduces the project task, explains and discusses the project context and, finally, informs the students of the expectations of the workshop. The second part entails executing the workshop. The teacher will make it run as planned, interact with the students while they work in project teams and, finally, prepare the contextual debriefing with the students, depending on each project team's questions. The third part of the workshop is the debriefing. The teacher has to bring it all together for the students, cementing the workshop learning objectives.

The third step in the learning cycle, guiding the project team, requires precise knowledge of course flow and understanding of how the project team is currently working. The teacher supervises the project teams. At the meetings the teacher and the students discuss the project results and the teacher guides each project team with practical useful information. Team building and project team energy must be effectively managed. The teacher normally guides the group by asking rather than telling. Initial questions to the students are used to

motivate, refocus and stimulate thinking. A prepared starting question encourages creative thinking and leads to a variety of possible answers. Guiding the project team also includes supplying students with historical projects to help them to get an overall picture of the project criteria.

During the learning assessments, the last step in the learning cycle, feedback is given to the students. At each milestone meeting, one student presents results from the project, normally using a computer and projector. The feedback is given to students both orally and in writing, and the teacher also explains the written feedback. Often, students are asked to redo some project work. At the milestone, each student makes an anonymous individual evaluation of his or her contribution to the project work. The results of these evaluations are discussed at the milestone meeting. If there are any problems within the project team, further project team meetings are held. The students also get more information about the project environment. For instance, they could look at presentation material from a similar project completed by consultants. Then the learning cycle starts again, beginning with interactive lectures and progressing according to the milestones in the project. In the final learning assessments the students start with a comparative analysis in which they compare their project work with that of another project team. A final rehearsal before the seminar, with individual presentations, is also held. On this occasion the project team practises presenting their project as they intend to do at the seminar. After the presentation the teacher provides a critique. Finally, students draw lots to determine which part of the project work each individual will present. At the final milestone the students also evaluate the project team agreement and the individual project work.

Every student also reflects on the experience of working in a project team, citing both the advantages and disadvantages of project work. These documents are left with the teacher at the seminar. It is important to be aware of the design of the seminar (Axelsson, Melin, Wedlund, 2006). The seminar is rehearsed at the location where the final seminar is to be presented. This location is a professional facility equipped for major presentations and with room for about a hundred listeners. The purpose of choosing this type of location is to train students under authentic conditions. The kinds of presentations they will give after graduation are often held in such facilities. An evaluation of the project's triple constraints – time, scope, and cost – is also made at the end of the project. The total for all project costs is calculated.

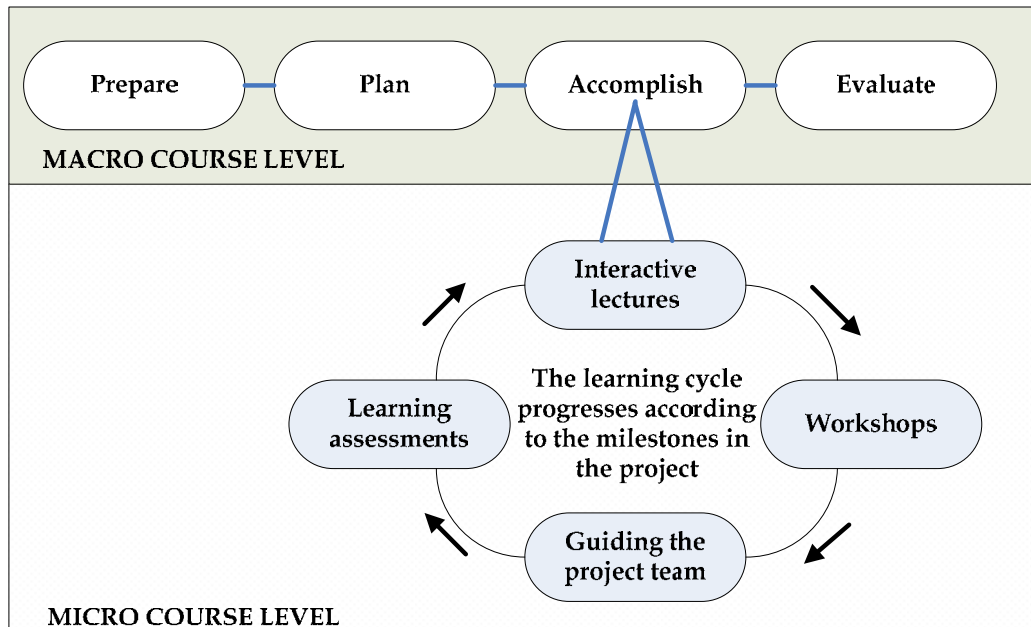


Figure 2. Designing a learning cycle in a course for project-based learning

#### 4. CONCLUDING DISCUSSION

This paper has presented a learning cycle for a project-based course. The learning cycle consists of (1) interactive lectures, (2) workshops, (3) guiding the project team and, finally, (4) learning assessments. The learning cycle progresses according to the project milestones. It is important for the teacher to switch focus between the macro and micro levels when developing a course for project-based learning.

The knowledge areas in a project-based course are the students' individual learning process, the project team process, the project environment, project management knowledge and application area. The teacher has to identify the strengths and weaknesses in the course in order to get the big picture of the course. The content in Table 1, below, helps the teacher to categorise the knowledge areas in a project-based course according to the steps in the learning cycle. The teacher can put data in the table during the preparation phase to discover any weaknesses in the course.

The time before the course starts is a very busy one for the teacher. Everything has to be prepared and planned in detail – preparation is the key to succeeding with a project-based course. The table below could be one way to determine which actions the teacher should take.

Table 1. Analysing strengths and weaknesses in a project-based course by using the steps in the learning cycle and the knowledge areas

Knowledge areas Steps in the learning cycle	The students' individual learning process	The project team process	Understanding the project environment	Project management knowledge	Application area
Interactive lectures					
Workshops					
Guiding the project team					
Learning assessments					
Summary of strengths and weaknesses					

#### 5. FUTURE RESEARCH AND LIMITATIONS

Further refinement of the learning cycle is needed, along with examples. Evaluation, verification and testing of the learning cycle in more regular course design are important future activities. In addition, it will be important to compare examples of strengths and weaknesses in different project-based courses. Another area that has to be investigated more deeply is the correspondence between the steps in the learning cycle and Kolb's model of students' individual learning processes.

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