Project-Oriented Education – Managing Three Simultaneous Processes

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ABSTRACT
In this paper, we describe how to manage teacher activities in three simultaneous processes in project-oriented education. We present these processes in the context of a project-oriented course and give examples of how teachers can apply them, both horizontally within a process and vertically in time between the processes. The examples are applied to the students' individual learning process, the project team process, and the project process. Students learn according to an individual learning process which begins by building on each student's concrete experience and ends by testing the new knowledge in new situations. Project teams can reach the performing stage only if they are able to work together to complete the project tasks; this is the project team process. The project process consists of understanding the project environment, project management knowledge, and the application area for the project. Project-oriented education has been applied to undergraduate courses at Linköping University. Experiences from these courses are discussed and analysed in the paper.

Keywords
Learning, learning cycle, project, project-oriented education, project process, project team process, skill, teacher activity

1. INTRODUCTION
Project work is growing, and more and more people are working on projects (Project Management Institute, 2004), sometimes using a project management model (Ericsson Project Management Institute, 2000). 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-oriented education (Grunnefeld and Silén, 2000; Melin and Cronholm, 2004; Wedlund, 2005; Weenk and Powell, 2003).

The purpose of this paper is to describe three simultaneous processes and give examples of teacher activities undertaken at the start of a course, during the execution of the course, and at the end of the 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.

This paper includes topics that are relevant to other university teachers who give courses that include projects for students, general courses of which information systems are a part – as is often the case in informatics courses (Schwalbe, 2005; Marchewka, 2006) – and, finally, specific information systems courses.

The paper is arranged in the following sections: section 2 presents a short description of the research approach, section 3 describes the three processes in a project-oriented course, section 4 discusses how to manage the three simultaneous processes, and section 5 presents concluding remarks and identifies areas for future work.

2. SHORT DESCRIPTION OF THE RESEARCH APPROACH
The research approach is qualitatively grounded (Strauss and Corbin, 1990) in theory and in the knowledge areas (Kolb, 1974; Tuckman, 1965; Project Management Institute, 2004) of the three processes, and in two years of practice in a prototype course called the Systems Development Project at Linköping University. The context for this paper is a development project at the Department of Computer and Information Science, Linköping University, Sweden. 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 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 of the course, in the middle of the course, and at the end of the course.

3. A PROJECT-ORIENTED COURSE
It is important for teachers to develop a deeper understanding of knowledge and practice in project management. There is a great deal of knowledge and practice that can be used in project education, for instance, how to prioritise among a project's triple constraints (Briner, et al., 1990), phases of a project life-cycle,

and how to develop team members' skills and knowledge (Cederling et al., 2000). The Project Management Institute (2004) defines a project as a temporary endeavour undertaken to create a unique product, service, or result. A project-oriented course normally comprises different processes. Within each process there are certain stages, steps, or phases. In a phase there are activities, which are components of work performed during the phase. A project-oriented course can therefore be divided into different time periods, often corresponding to the same phases as the generic project life-cycle. The project life-cycle defines the phases that connect the beginning of the project to its end. The phases make the project more measurable and manageable, as in figure 1, which contains the following five phases: define project, plan project, execute project, close project, evaluate project.

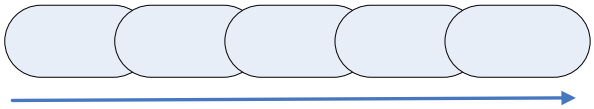

Figure 1. A generic project life-cycle

Project-oriented education includes skills training for the students. The students improve their skills while they work with the activities in the processes within the project phases during the course. These skills can be categorised into two parts, depending on the decisions made about which activity to do and how to do it. This is also an important issue in industrial projects, such as global product development projects (Wedlund, 2000). Some important considerations for project-oriented education are how these teaching methods, the project environment, and the students' learning backgrounds can predict the quality of the learning outcomes. One of the purposes of a project-oriented course is to foster student-centred learning (Gibbs, 1995). During the phases in the generic project life-cycle the students learn about:

- The individual learning process, beginning with concrete experience, within the first process
- Group dynamics, within the second process
- The project environment, as described in a case study, within the third process
- Project management knowledge, within the third process
- The course content, from the application area, within the third process

Ramsden (2003) argues that higher education is a part of what he sees as a "global shift to a new way of creating and using knowledge". Project-oriented education is a good example of this new way of creating and using knowledge. It encourages teachers to use more knowledge areas than they would in a normal university course. The knowledge areas in the three processes usually belong to different faculties within a university. Project-oriented education also encourages deep learning (Biggs, 2003) among the students. The teacher designs learning situations which motivate the students and encourage them to be active in their own learning processes. The students then participate in activities in the processes, in problem solving, summarising and digesting new information to fundamentally change the way they think about and use information. The information is used in various phases in the project while the students are working with analysis, design realisation, and tests in the course. The case we use as an empirical example in this paper is taken from a course which is an introduction to the various phases in the systems development process. These phases include analysis, design, realisation, and tests. The aim is to complete and document a systems development project from systems analysis to realisation. The students develop a website for electronic commerce. The course is given full-time during a fifteen-week period and is taken by approximately 45 students each year. The course components mentioned are integrated in a natural way during the course so that students become familiar with and gain abilities in the various phases in a systems development project.

3.1 The students' individual learning process

The students' individual 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
- Testing in new situations

Kolb argues that the learning cycle can begin at any one of the four steps and that it should really be approached as a continuous movement. However, it is suggested that Kolb's learning cycle often begins when, for example, a student is carrying out a particular action and then seeing the effect of the action in a new situation.

This process begins with students' concrete experience (see figure 2).

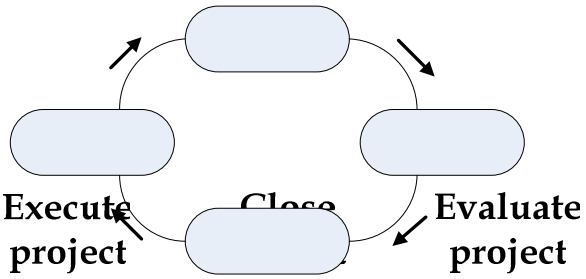

Figure 2. Kolb's steps in a learning cycle (Kolb, 1974)

The second step is observation and reflection, the third step is forming abstract concepts, and, finally, the fourth step is testing in new situations. A teacher who has learned to teach in this way may well have various rules of thumb or generalisations about what to do in different learning situations. It is important to start with students' "here and now" experience. In a project-oriented course, written and oral feedback are given to the students at milestones in the project, normally every second week. A workshop, designed by the teacher based on the students' concrete experience, is used. If learning has taken place, the process could be seen as a spiral. Once the action has taken place in a different set of circumstances, the teacher can anticipate the possible effects of the action. The teacher's earlier experience is important, particularly when the students solve problems in the information systems area.

3.2 The project team process

The project team process is the second process in project-oriented education. 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 (students) needs to experience all four stages before it achieves maximum effectiveness. In project-oriented education the project teams comprise four to six students. Normally the students go through two stages of group development. If the project team is successful, students can sometimes reach the third stage.

The four stages of project team development are:

- Forming
- Storming
- Norming
- Performing

During stage 1, Forming, students want to be accepted by the other students and avoid conflicts. Serious issues and feelings are avoided, and students often focus on the details of the project work, such as who does what, when to meet, etc. But students are also gathering information and impressions about each other and about the project scope. During stage 2, Storming, students in the project team become less carefully polite to each other as they start to address important issues. Some students' patience breaks early, and minor confrontations arise. These may relate to the project work of the team itself, or to roles and responsibilities within the project plan. Every project team normally reaches this stage. During stage 3, Norming, the rules in the project team, which evolved in stage 2, become established, and the scope of the project team's tasks or responsibilities is clear and agreed upon. Having had their arguments in the project team, team members now understand each other better and can appreciate each other's skills and experience. Students listen to each other, appreciate and support each other, and are prepared to change pre-conceived views. Few project teams reach this stage. Stage 4, Performing, is very seldom reached by project teams. This stage is characterised by a state of interdependence and flexibility. Everyone in the project team knows the others well enough to be able to work together, and they trust each other enough to allow independent activity. Project roles and responsibilities change according to need in an almost seamless way. Project team identity, loyalty, and morale are all high, and everyone is equally task-oriented and student-oriented. "Increased performance" in figure 3 means that the project team can reach another stage in its development. "Decreased performance" means the opposite. It normally applies when a project team reaches stage 2, Storming.

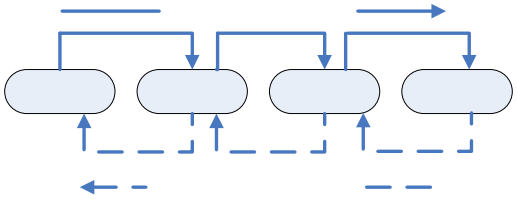

Figure 3. Tuckman's stages of project team development (Tuckman, 1965)

3.3 The project process

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, project management knowledge, and application area (see figure 4). Areas that are excluded in this paper and study are general management knowledge and skills, and interpersonal skills.

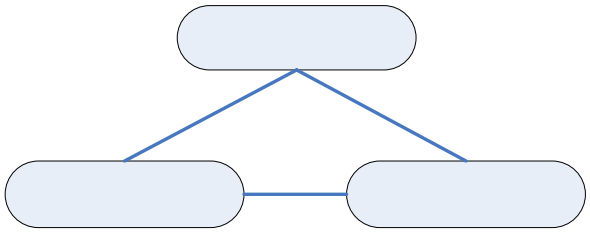

Figure 4. PMI's (Project Management Institute's) areas of expertise needed by the project team (partial, Project Management Institute, 2004)

All projects are executed in a project environment, which consists of information about the organisational culture. This culture could be reflected in factors such as:

- Stakeholders' beliefs and expectations about the project
- Business processes in the organisation
- Goals
- Problems and strengths
- Views of authority, for example the project sponsor

The area of project management consists of knowledge unique to the project management field. This knowledge is described in nine knowledge areas (Project Management Institute, 2004): integration, scope, time, cost, quality, human resources, communications, risk, and procurement. In total, there are 44 project management processes. Examples of important project management processes include:

- Development of a project management plan
- Monitoring and controlling project work
- Performance reporting
- Scope control

Each application area generally has a set of accepted standards. The course, an information systems course, is in this application area. These standards for an information systems course are usually defined in terms of, for example, information systems development work. This development could be in software development, as in this course or engineering courses in other courses. In this course the students work with Rational Unified Process (Kruchten, 2003). Rational Unified Process consists of four phases:

- Inception
- Elaboration
- Construction
- Transition

In university courses in information systems it is common for students to work with systems development models, for example Rational Unified Process. The milestones are life-cycle objective, life-cycle architecture, initial operational capability, and product release.

4. MANAGING THREE SIMULTANEOUS PROCESSES

This section contains examples of how a teacher can manage the three processes in a project-oriented course. The start of the course is about two weeks long. After the start comes the course execution, which, in this course, takes about eleven weeks to complete. Then, over two more weeks, the course ends. Figure 5 summarises the processes related to the time in the course. It is a generic figure; the project execution may take more or less time in another course where students work with a project.

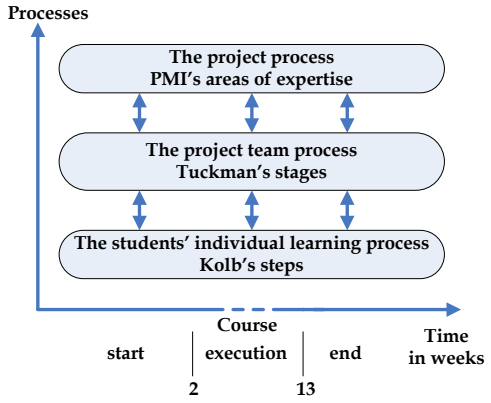

Figure 5. Managing three simultaneous processes in a project-oriented course

The teacher carries out the following sixteen activities to manage the processes:

1. Assess the project's current status
2. Design scheduled milestones
3. Design workshop
4. Establish student evaluation methods
5. Evaluate students' contribution to the project
6. Examine
7. Give lectures
8. Organise guest lectures
9. Organise project team meetings
10. Organise student presentations
11. Plan how project teams should be divided
12. Plan opposition
13. Plan seminar
14. Provide feedback
15. Supervise student work
16. Supply material

4.1 At the course start

The time before the course starts is a very busy one for the teacher. Everything has to be planned and organised in detail, for all three processes, and there is always a lot of practical work to do. At the start of the course the students need to get an overall picture of the project. One way to do this is to supply students with an earlier project completed by other students. It is important that the project team be able to write a project team agreement (Olsson, 2004). It can be helpful to supply the project team with examples of historical project team agreements and to organise project team meetings. The project team also needs information about the project environment; different stakeholders' expectations are therefore described in a case. In a project plan all the milestones are scheduled. A workshop is also designed to introduce the students to the application area (see table 1).

Table 1. Examples of teacher activities at the start of a course

Process		Examples
The students' individual learning process Kolb's steps		Supply students with historical projects to help them to get an overall picture; include documentation and information systems and criteria for the project Supervise students
The project team process Tuckman's stages		Supply project teams with examples of historical project team agreements Give lectures about the stages in the project team process and how to handle conflicts in the project team Divide into project teams Organise project team meetings, where students could come to a project team agreement Supervise project teams
The project process PMI's areas of expertise	**Understanding the project environment**	Supply students with a description of the case in the project Give lectures about the case in the project
	Project management knowledge	Supply students with parts of a template for a project plan Give lectures about what to do during the initiating and planning phases of the project
	Application area	Give lectures about the application area Design a workshop

4.2 The course execution

During the course execution, the teacher schedules a milestone meeting every second week. At each milestone meeting, one student presents results from the project, normally using a computer and projector. The teacher and the students then discuss the results. After that, the teacher assesses the project's status, and both documentation and information systems are assessed. Feedback is given to the students, usually within three days. The feedback is given to students in writing, and the teacher also explains the written feedback to them. Often, students are asked to redo some project work (see table 2).

The students schedule meetings which are held in team rooms located at the university. The team rooms can be booked in advance. Student project teams can also reserve computers to use when working on their projects. Each project team evaluates the written project team agreement at every milestone; if the agreement has been followed the project team does not have to make any changes to it, otherwise the agreement has to be updated. The new agreement is then signed by every student on the team.

At the milestone every student also 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.

There are five types of roles in the project team: analysts, developers, testers, project managers, and additional roles. During the project these roles shift among the project members. The students are informed about the tasks involved with each role, and they then allocate the roles themselves. The purpose is to allow every student to take the project manager role during one phase of the project. The project team also has scheduled mandatory supervision; these supervised sessions are normally half an hour long.

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. Guest lectures also present the views and expectations of various stakeholders. During the guest lectures, the students can ask questions to get a broader perspective of the case in the project.

The students also have lectures about what to do during the executing, monitoring, and controlling phases of the project. They could then, for instance, report on their performance in the project and evaluate the project's triple constraints – time, scope, and cost – within the project plan. The scope control is especially important for the students; it is described in the software requirements specification. Performance reports are documented in the project plan, which contains information about the project work progress and status.

The teacher designs an introductory workshop on how to design an information system in the application area. In this case, a workshop of conceptual models in the design area is used. The workshop begins with a student presentation on how they worked during this course phase. It is important to meet the students at their knowledge level.

The students follow the milestones in the application area during the execution of the course; in this case the milestone is life-cycle architecture. The milestone in the application area is coordinated with the scheduled milestones in the project.

Table 2. Examples of teacher activities during course execution

Process		Examples
The students' individual learning process Kolb's steps		Design scheduled milestones meetings, every second week Earlier students' presentation Assess the project's current status, both its documentation and information system Provide feedback, both oral and written, continuously Supervise students
The project team process Tuckman's stages		Organise project team meeting Evaluate project team agreements, on every milestone Evaluate students' individual contributions to the project Allocate the project team roles, according to the roles in Rational Unified Process Supervise project teams
The project process PMI's areas of expertise	**Understanding the project environment**	Supply students with material from the project environment to present other perspectives Organise guest lectures to present different stakeholders' expectations
	Project management knowledge	Give lectures about what to do during the executing, monitoring, and controlling phases of the project Complete performance reports; this includes status reports in the project plan Assess the project's triple constraints – time, scope, and cost – within the project plan
	Application area	Design an introductory workshop on designing an information system Give lectures about the application area Follow the milestones in the application area life-cycle architecture

4.3 At the course end

The project team's last milestone, initial operational capability, is reached about two weeks before the end of the course At this milestone the project team gets information about their opponent. The opponent is another project team which critiques both the project documentation and the information system. Instructions for this critique are given to the project team at the last milestone.

The students start with a comparative analysis, in which they compare information systems with another project team. This comparison is based on the software requirements specification, which is known from the execution phase of the project. When the comparison is made, the students write a comprehensive opinion about their own project and that of the other project team. The students also test another information system, document test results, and write a test evaluation summary.

A final rehearsal before the seminar, with individual presentations, is also held. On this occasion the project team practises presenting their project, making the presentation 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 one will present individually.

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.

The locale for the final rehearsal before the seminar is the same as the locale for the seminar. This locale is a professional presentation facility equipped for major presentations and with room for about a hundred listeners. The purpose of choosing a locale like this is to train students under authentic conditions. The kinds of presentations they will give are often held in such facilities. The students should also compare the developed information system with the commercial information system. It is important for the students to get a broader perspective of the functionality in a commercial information system.

The students also attend lectures about what to do during the closing phase of the project. Lectures include historical information and information on lessons learned; this information is transferred to the lessons learned knowledge base for use in future projects. All project documentation resulting from the project's activities has to be filed. An evaluation of the project's triple constraints – time, scope, and cost – is also made at the end of the project. The total sum for all project costs is calculated.

The teacher also gives lectures about the application area. In this case there are, for instance, general lectures about test cases and test data. The students follow the milestone in the application area, which is initial operational capability.

After the seminar (Axelsson et al., 2006) the teacher assesses the project and provides feedback to the students. Finally, the project work is examined. At the end of the course the students do individual written examinations. These examinations are based on the knowledge in the application area. At the end of the course all the processes are evaluated by the students (see table 3).

Table 3. Examples of teacher activities at the end of a course

Process		Examples
The students' individual learning process Kolb's steps		Conduct a comparative analysis of the information system
		Test the information system
		Hold the final rehearsal, with individual presentations
		Assess the project's current status, both documentation and information system
		Examine the project
		Provide feedback
		Obtain student evaluations
The project team process Tuckman's stages		Evaluate project team agreements, at the end of the project
		Evaluate students' individual project work in the project team, at the end of the course
		Individual reflection of the project
		Obtain student evaluations
The project process PMI's areas of expertise	**Understanding the project environment**	Present the project under authentic conditions
		Compare the developed information system with commercial information system
		Obtain student evaluations
	Project management knowledge	Give lectures about what to do during the closing phase of the project
		Evaluate the project's triple constraints – time, scope and cost – at the end of the project
		Obtain student evaluations
	Application area	Give lectures about the application area
		Following the milestones in the application area, initial operational capability
		Hold individual written examinations
		Obtain student evaluations

4.4 Planning the three simultaneous processes

As mentioned above, the teacher has to manage sixteen activities in this course. All of these activities have to be planned before the course starts. The students later evaluate these activities, normally two weeks into the course. This evaluation is a so-called muddy-cards evaluation. Each student writes down constructive criticism on a small card. The cards are collected and then the students get a written and oral response to the criticism. The teacher usually resolves some minor issues quickly and discusses them with the students during a lecture.

In the middle part of the course, another evaluation is done, and when the course ends a final evaluation is done by the students. The questions in these evaluations are based on the teacher activities in the three processes, and the questions can be categorised according to the three processes. After the course has ended the teacher also evaluates the course and meets with the director of studies and a student representative to discuss changes to the course. Then the teacher starts to plan the next course, during course planning (see figure 6).

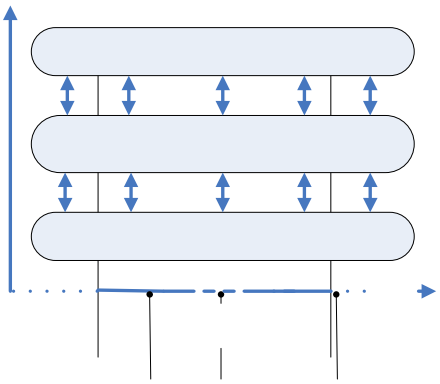

Figure 6. Planning three simultaneous processes in a project-oriented course

5. CONCLUSIONS AND FURTHER STUDIES

In this paper we have highlighted four central concepts: student, project team, project activity, and teacher activity. These concepts are the central parts in the three simultaneous processes in a project-oriented course: the students' individual learning process, the project team process, and the project process. We have also given examples of teacher activities conducted at the start of a course, during the execution of the course, and at the end of the course. It is important for teachers to be aware of these processes and to manage them consciously, both horizontally within a process and vertically in time between the processes. It is therefore a challenge for the teacher to conduct a project-oriented course because so many activities have to be completed A course is normally several weeks long; in this case, it is fifteen weeks long. One way to accomplish this work is to divide the teacher's work into five smaller parts: course planning, course start, course execution, course end, and major course evaluation. A great deal of work has to be done during the major course evaluation and the course planning. Without a distinct connection between the activities in the processes, the students might find that performing some activities seems meaningless in relation to the project; timing the activities appropriately in the course is an essential part of the course planning for the teacher.

Getting this timing right is easier if the teacher has experiences from earlier project courses and practical experience from "real" projects in the project environment, which is described in the case in the project. Another way is to provide guest lectures for the students, and to "prepare them for the types of situations they will encounter in their future work" at scheduled milestones meeting. At these milestone meetings, the teacher provides feedback, both oral and written, on the documentation in the project, the information system, and on students' performance in the project.

We want to give students the opportunity to express what they have learned during the milestones meeting and to learn further from others in the project team and from the dialogue with the teacher. The students are also supplied with historical project experiences of other students. In order to reach all the goals in the project and in the course we have to design the assessment event and seminars carefully.

The three processes come from separate disciplines, which makes the teacher's knowledge and skills essential. The teacher needs to have knowledge about the application area in the course; this knowledge area is usually the teacher's area of greatest strength. The other knowledge areas are usually much more difficult for a teacher to manage; these knowledge areas are the students' individual learning process, the project team process, understanding the project environment, and project management knowledge (see figure 7).

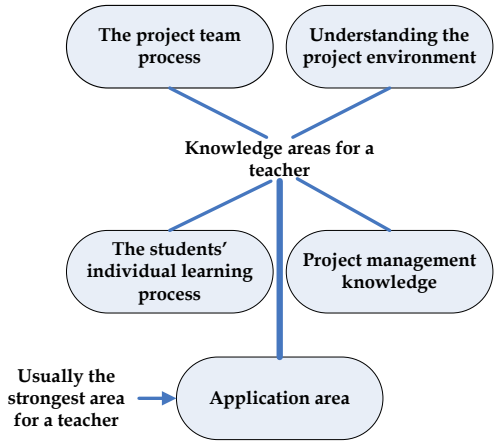

Figure 7. Knowledge areas for a teacher in a project-oriented course

Four evaluations are made during the course; the first evaluation is the muddy-cards evaluation. It is important to have an evaluation after about two weeks in the course. The students are involved early in the feedback process with the teacher, and it is usually easy to resolve any problems that the students have

encountered. There are two other evaluations for the students, and, finally, the teacher evaluates the course.

Finally, we have formulated our findings into some advice for teachers who want to design and perform a project-oriented course:

- Divide the planning work for a project-oriented course into three processes: the students' individual learning process, the project team process, and the project process
- Manage the activities in the three processes, both horizontally within a process and vertically in time between the processes
- Organise the teacher's planning work into five periods: course planning, course start, course execution, course end, and major course evaluation
- Meet the students "here and now", and let them test their new knowledge constantly in new situations in the project
- Plan, organise, and support the norming phase of the project team carefully, particularly the outcome of the division of the students into project teams
- Divide the project process into three parts: understanding the project environment, project management knowledge, and application area for the project
- Let the students know about "authentic issues" from the project environment during the project
- Plan, organise, and provide oral and written feedback continuously to the students
- Evaluate project team agreements at every scheduled milestone, and try to determine in which stage of the project team development each project team is
- Give lectures about what to do during the executing, monitoring, and controlling phases of the project
- Plan and organise performance reporting, based on the project plan
- Assess, examine, and provide feedback, based on the initial known criteria for the students in the project
- Support individual reflection on the project, and the lessons learned from the project team process, for example the norming and storming phase
- Combine oral examination with written examination, and individual examination with project team examination
- Evaluate the course at several stages
- Improve the teacher's knowledge in the knowledge areas in a project-oriented course, particularly in the teacher's "weak" areas
- Develop a toolbox with teacher activities at course start, course execution, and course end

Finally, more studies are needed in order to take our findings further. It would be interesting to manage the three processes, both horizontally within a process and vertically in time between the processes, in different courses to find more examples of teacher activities. It would also be interesting to further categorise, analyse, and evaluate the teachers' activities in a project-oriented course and relate to other subject areas. Additional studies could also be done, where the content in a project-oriented course is related to the nine knowledge areas in project management (Project Management Institute, 2004). A practical handbook on how to manage the three processes with techniques, course design, case examples, and tips, like Silberman's (1998), is also needed. Another interesting study would of course be to further evaluate the students' opinions.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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