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Case Study of Teamwork Coordination in Teaching Energy Engineering Sciences

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Abstract

Teamwork is the student outcome that means the ability to function on multidisciplinary teams. Teamwork is one of the most frequent ability involved in recent science and engineering courses. Team assignments should be structured to assure positive interdependence (that is, if anyone on the team does not fulfill his or her responsibilities, everyone is penalized in some manner), individual accountability for all the work done on the project, face-to-face interaction (at least part of the time), development and appropriate use of interpersonal skills, and regular self-assessment of team functioning. However, promotion of teamwork is not spontaneous but very often requires the use of self-regulation within teams. The aim of the paper is to elucidate if self-coordination and planning of teamwork is useful to promote teamwork. The paper shows a case study on the use of self-coordination of teams within active teaching strategies that involve teamwork as a critical skill. The paper presents first the fundamentals of the learning strategy adopted, intended to develop teamwork abilities in the students. It then describes the context and challenges faced up in the case study, as well as the essentials of the learning activities proposed. The topic involved in this experience is the electrical installations engineering science, an energy engineering science. Four sets of students with a total number of 50 participate in the experience during the periods 2010/11, 2011/12, 2012/13 and 2013/14. The teams of four members were formed. At the beginning of the course, every team developed its own schedule and internal task assignment to face up the task in charge, along four months of teamwork. Finally, the paper discusses the student's achievement and perception related to the self-coordination and self-planning mechanisms adopted. The paper could be of interest to those readers that want to promote teamwork as a critical skill in other science courses.

1. Introduction

Many lecturers believe that simply giving three or four students something to do together—a laboratory experiment and report, for example,—should somehow enable all of them to develop the skills of leadership, time management, communication, and conflict resolution that characterize high performance teams. Very often, no one of these improvements happen. Under such circumstances, the most frequent is that one or two students do most or all of the work, and all students get the same grade. This does not promote development of teamwork skills.

The aim of the paper is to elucidate if self-coordination and planning of teamwork is useful to promote teamwork. The paper presents first the fundamentals of the learning strategy adopted, intended to develop teamwork abilities in the students. It then describes the context and challenges faced up in the case study, as well as the essentials of the learning activities proposed. Finally, the paper discusses the student's achievement and perception related to the self-coordination and self-planning mechanisms adopted.

2. Teamwork as critical skill in cooperative learning

Following Felder at al. [1], cooperative learning is an instructional approach in which students work in teams on a learning task. The task presents several features: (i) there must be a clearly defined group goal that requires involvement of every team member to achieve; (ii) each student in the team is held responsible for doing his/her share of the work and for understanding everyone else's contribution; (iii) Although some of the group work may be parcelled out and done individually, some must be done interactively, with team members providing one another with questions, feedback, and instruction; (iv)

Students should be helped to develop leadership, communication, conflict resolution, and time management skills; (v) Teams should periodically be required to examine what they are doing well together and what areas need improvement.

Some suggestions to help lecturers to implement cooperative learning and teamwork could be found in references [1-4]. One of the key concepts to develop teamwork is the promotion of positive interdependence. Assigning roles, for example, the manager (organizes the assignment into subtasks, allocates responsibilities, and keeps the group on task), the recorder (writes the final report or problem solution set, or for large projects, assembles the report), or the checker (proofreads and corrects the final report before it is submitted) could be of help in this task. The role assignment depends on the complexity of task and the time the team will be working together.

3. Case study of teamwork coordination in energy engineering sciences

The experience described in next paragraphs has been developed in engineering science topics belonging the seventh semester of a four-year, eight-semester undergraduate program leading to a degree in Electronics and Control Engineering at the Higher Polytechnic School of the University of Burgos (Spain), as shown in Table 1.

Table 1. Electronics and Control Engineering Degree at the University of Burgos

First Year			
1st semester	***ECTS credits***	***2nd semester***	***ECTS credits***
Physics I	*6*	*Physics II*	*6*
Mathematics I	*6*	*Mathematics III*	*6*
Mathematics II	*6*	*Chemistry*	*6*
Technical Drawing	*6*	*Materials Science*	*6*
Computers I	*6*	*Economics*	*6*
Second Year			
3rd semester	***ECTS credits***	***4th semester***	***ECTS credits***
Engineering Thermodynamics	*6*	*Fluid Mechanics Engineering*	*6*
Statistics	*6*	*Electronics Fundamentals*	*6*
Electrical Engineering Fundamentals	*6*	*Mechanic*	*6*
Production Management	*6*	*Theory of Circuits*	*6*
Elasticity and Strength of Materials	*6*	*Automation & Industrial Control*	*6*
Third Year			
5th semester	***ECTS credits***	***6th semester***	***ECTS credits***
Electrical Machines	*6*	*Power Electronics*	*6*
Regulation & Control	*6*	*Microprocessor Systems*	*6*
Digital Electronics	*6*	*Electronics Instrumentation*	*6*
Analogical Electronics	*6*	*Industrial Automation*	*6*
Electronics Technology	*6*	*Production and Manufacturing Systems*	*6*
Fourth Year			
7th semester	***ECTS credits***	***8th semester***	***ECTS credits***
Computers II	*6*	*Industrial Automation*	*6*
Technical Projects	*6*	*Industrial Robotics*	*6*
Opt Module I (Electrical Installations)	*6*	*Final Project*	*18*
Optional Module II	*6*		
Optional Module III	*6*		

In the topic "Electrical Installations" (optional, 4th year, 7th semester), a structured problem based learning (PBL) approach was adopted, based on the previous experience of the teachers [5]. This optional module aims to impart a fundamental knowledge on electrical installations, with a special focus on industry and buildings. The students are asked to carry out a parametric energy analysis of an installation in terms of electricity demand, energy efficiency and electrical safety. The open problem involves all the learning outcomes of the topic and is the frame of all the activities at the classroom and laboratory during the semester. Students are committed to prepare a report on the specific problem on energy analysis, to be ready after a period of five months.
Previous works of the authors deal with self-regulation of teamwork [6]. This work deals with coordination and planning of teamwork. It refers to the ability of teams to prepare a work-plan including the tasks schedule, assignment to every participant, and coordination activities.

4. Discussion and Conclusions

During the academic years 2010/11, 2011/12, 2012/13 and 2013/14, the study module has been being taught using the aforementioned structured cooperative learning approach. A total number of 48 students participated, distributed in teams of four people (12 teams). At the beginning of the semester, the teams were suggested to prepare its respective work-plan concerning the tasks in charge, once the teacher had explained the course organization and the expected learning outcomes. The teacher emphasized the potential benefits of having such work-plan, also gave some hints on how to prepare it, but in a general manner. The activity was optional, then not all the teams prepare the work-plan. From the 12 potential teams to participate, at last only 8 teams presented its work-plan, which means a 67% of acceptance of the proposal. It was considered a good result for the first time.
Each team was assigned a coordinator by the teacher. Teams were asked to prepare a simple form of the work-plan, not much time consuming. The work-plan was discussed by each coordinator with the teacher trough a personal interview. For comparison purposes, every work-plan received could be classified in several categories:

- Schedule: There exist deadlines for partial and final task. It shows the calendar of the semester or weekly programming, with marked tasks and deadlines.
- Task assignment: every member is responsible for a defined task.
- Teamwork strategy: Every member of the team works each task individually and then coordination meetings allow final decision (more efficient learning); or the team works all the tasks together through discussion to get final decision (less efficient learning, some members could be inactive).

Table 2 shows the distribution of the set of work-plan amongst the categories. We can see that the teams found no difficulty to divide the task into subtasks, but it was not so easy to place deadlines.

Table 2. Distribution of the set of work-plan amongst categories

Category 1: Schedule		**Category 2: Task assignment**		**Category 3: Team strategy**	
Full detailed deadlines and tasks	5	Every member has a clearly defined task	1	Every member works each task individually and then coordination meeting	3
Tasks are defined but only a few deadlines	1	Only some members have a defined task	0	All the members work together all the tasks through discussion	3
Tasks are defined but no deadlines at all	2	No task is defined for every member	7	No information at all	2

Near all the teams were not able to distribute tasks to every member at the beginning, though they did it afterwards. Team strategy was the initial weakest ability. As stated at the personal interviews with the coordinators, teams tend to promote full member discussion-meetings under the believe that it would easier to progress. Only some teams recognized the advantages of previous personal work (development of personal creativity and learning) and then contrast the personal vision with those of others.

At the end of the semester, the teacher maintained personal meetings with every team, all members. Table 3 presents a summary of the results.

Table 3. Distribution of results of students perception on team functioning

Degree of full-filling of the work-plan	100%-91%	90%-81%	80%-70%	<70%
	0	3	4	1
Work-plan serves as guide	YES		NO	
	3		5	
Will use work-plan in future	YES		NO	
	8		0	
Tasks planned in vacation days	YES		NO	
	4		4	

Concerning the degree of filling the initial task distribution, schedule and deadlines, most of teams declared have kept the plan at range 70-80%. Some teams performed as high as 90%, but none of them considered overcome this score. At least one team stated a bad performance, under 60%. That means that teams, at this stage of maturity and experience (4th semester) are mostly able to perform useful plans for teamwork.

Another question referred to if the initial work-plan had been served as a guide during the semester. Most of the teams declared (5 of 8) not have used anymore the plan after presenting it to the teacher at the beginning of the semester. It can be assumed that these teams could work in an intuitive manner even without planning. However, the three teams that state they have used the work-plan at meetings to check progress were the same that declared 90% of keeping, showing correlation between the two parameters. It can be concluded that work-plan could improve significantly team performance when used as a guide to check plan progressing.

Unanimous agreement existed about the usefulness of work-plan for future teamwork tasks. All the teams recognized that planning increases the performance and efficiency of the team.

The last question concerned a surprising item found out in the work-plans. Four teams have planned to work during vacation days (mostly 15 days at Christmas holydays), and effectively did it, instead of completing the task in charge along the teaching period. The query posed by the teacher to students was if they perceived it as a good practice, as well as present learners as well as future engineers. During vacation days those students were still working, not resting or making some other necessary activities that contribute to their higher education (social relations, sports, cultural events, tourism, etc.). Some students were puzzled by the question and they recognized such practice as a bad one. The teacher emphasizes the need of completing the assigned task during the working period as a good professional practice. Four teams did not plan working in vacations days, but two of them finally did it as a need because unexpected delay.

We conclude that planning of teamwork is a useful tool to improve team functioning and effectiveness. Emphasis on explaining to students common rules to plan teamwork should be stressed in next courses. The use of assigning the coordinator role has been shown to be useful to allow team internal discussion of suggestions done by the teacher. Nevertheless, intermediate meetings with the coordinator could improve feedback to the team, for example promoting the use of the work-plan as a true guide for performance.

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