The Use of Rubric-Based Method to Assess Teamwork Skill Development. A Case Study in Science and Engineering Courses

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Abstract

At present, most of science and/or engineering programs at high schools and universities describe what the students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program to prepare graduates to attain the program educational objectives. Among the course components, the successful achievement of the scientific objectives is clearly a basic assessment of the technical work and a good demonstration of the student's level of understanding. However, other components, including project planning and research methodology skills, critical thinking and formulating research questions, data collection and analysis, interpersonal communication and team behaviors, are definitely important outcomes of the course. For this reason, a set of rubrics were devised to assess each component of the grading policy through defined primary indicators for each activity. The paper presents a case study of teamwork skill development within the scope of science teaching in electronics engineering curricula. A problem-based learning approach was used to lead the learning process of the students. The aim of the paper is to check if the use of rubrics for teamwork assessment is a useful method in terms of easiness and short time of application, and alignment with the active teaching approach adopted. A set of 50 students were involved, during the fall semester of 2013, in the experience of developing a energy audit of an industrial heat and power station. A term paper assignment was given to students, organized in teams of four members. The expected outcomes are the ability to perform the technical analysis of the industrial station in terms of mass and energy balances, and the development of personal skills such as data collection and analysis, problem-solving, critical thinking, teamwork, autonomous learning and the ability to apply theoretical knowledge to practice. A rubric was developed, intended to assess teamwork, with the requisite of being easy to understand by the students and short time consuming to fulfill it. Analysis of student's response is presented. Teacher's perception of the experience was obtained by means of personal interviews. The paper could be of interest to those readers that want to promote skill development in other science courses.

1. Introduction

Rapidly changing technology means that graduates of engineering programs need to acquire important qualities of lifelong learning and self-learning to support a through-life ability to respond to advances in technology. Amongst them we could mention skills such as teamwork, creative thinking, communication or critical self-awareness. The industry [1] demands and expects from engineers a wide range of these generic skills in addition to a high degree of technical competence. Also, some engineering institutions and associations [2, 3] include this appreciation in their reports. The learning and development of these skills is only possible if, as much as the scientific knowledge, their achievement is a self-building process of the student. In turn, the teachers must become guides in the process of a learning which is not limited only to the topic of their own course, but which must be imbedded with a good dose of these skills.

The use of cooperative work as a teaching strategy can help to improve students' sense of responsibility for their own learning by fostering group cohesion and positive interdependence among peers. The paper presents a case study of teamwork skill development within the scope of science teaching in electronics engineering curricula. A problem-based learning approach was used to lead the learning process of the students.

Cognitive skills, such as teamwork, are difficult to measure with a conventional "test", graded for correct versus incorrect answers. However, a rubric can allow characterizations of student thinking or understanding. A rubric is an assessment tool that identifies features that student work should have, along with several levels of quality of student work that might be associated with each feature. The aim of the paper is to check if the use of rubrics for teamwork assessment is a useful method in terms of easiness and short time of application, and alignment with the active teaching approach adopted.

2. Rubric-Based Method to Assess Teamwork Skill in Energy Courses

The experience described in next paragraphs has been developed in science topics belonging the third 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. The set of first to fourth semesters are devoted to basic engineering sciences, and they are the same in any of the engineering degrees related to industry concerns (mechanics, electronics, control, industrial management, etc.) at the University of Burgos. All the modules are taught over a period of 15 weeks and involve four hours of timetable contact per week (2 classroom/theory hours, 2 seminar/laboratory hours), for a total workload of 6 ECTS credits.

In the topic "Engineering Thermodynamics" (compulsory, 2nd year, 3rd semester), a structured problem based learning approach was adopted. This compulsory module aims to impart a fundamental knowledge on Thermodynamics and Heat Transfer, with a special focus on energy analysis of basic heat and work fluid processes. At the beginning of the course an open problem of industrial energy analysis is assigned to the students, following the PBL approach. The full details of the experience can be found in reference [4]. The students are asked to carry out a parametric energy analysis of the installation in terms of fuel consumption, energy production and CO_2 emissions, depending on certain range of pressure and temperature of fluids. 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 [5]. This work deals with teamwork skill development. There exist several literature references on the use of rubrics in engineering education [6-8]. The authors developed a rubric to evaluate five elements of team work: (i) Contribution to teamwork; (ii) Taking responsibility; (iii) Individual contribution outside of team meetings; (iv) Promotion of constructive team climate; (v) Response to conflict. The rubric is presented in Table 1.

Table 1. Rubric for ability to function in teams

Definition: Teamwork is behaviors under the control of individual team members (effort they put into team tasks, their manner of interacting with others on team, and the quantity and quality of contributions they make to team discussions.)
Instructions: Please rate YOURSELF & YOUR TEAM MEMBERS using the provided table. Please fill in the table below honestly, and as accurately as possible. Please use the following rating scale: 3-Excellent; 2-Good; 1-Needs improvement; 0-Unacceptable

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1 Contribution to teamwork					
Level	Description	Member 1	Member 2	Member 3	Member 4
3	Collect and present to the team a great deal of relevant information; offer well-developed and clearly expressed ideas directly related to the group's purpose				
2	Collect basic, useful information related to the project and occasionally offer useful ideas to meet the team's needs.				
1	Collect information when asked for and try to offer some ideas, but they are not well developed, or not clearly expressed, to meet team's needs.				
0	Fail to collect any relevant information or give useful suggestions to address team's needs.				

2 Taking responsibility					
3	Perform all assigned tasks very effectively, attend all team meetings, participate enthusiastically, and remain very reliable.				
2	Perform all assigned tasks, attend team meetings regularly, and usually participate effectively and reliably.				
1	Perform assigned tasks but needs many reminders, attend meetings regularly but generally do not say anything constructive, or eventually expect others to do his/her work.				
0	Fail to perform assigned tasks, often miss meetings, do not have any constructive contribution when present, or usually rely on others to do the work.				

3 Individual contribution outside of team meetings					
3	Completes all assigned tasks by deadline; work accomplished is thorough, comprehensive, and advances the project. Proactively helps other team members complete their assigned tasks to a similar level of excellence.				
2	Completes all assigned tasks by deadline; work accomplished is thorough, comprehensive, and advances the project.				
1	Completes all assigned tasks by deadline.				
0	Frequently, does not complete the assigned tasks by deadline				

4 Promotion of constructive team climate					
3	Always listen to others and their ideas, help them develop their ideas while giving them full credit, and always help the team to reach a fair decision.				
2	Generally listen to others' points of view, always use appropriate and respectful language, and try to make a definite effort to understand others.				
1	Usually do much of the talking, do not pay much attention when others talk, but avoid personal attacks and put-downs although sometimes patronizing.				
0	Often argue with team mates, do not let anyone else talk, have occasional personal attacks and "put-downs", want to have things done his/her way, or do not listen to alternate approaches.				

5 Response to conflict					
3	Addresses destructive conflict directly and constructively, helping to manage/resolve it in a way that strengthens overall team cohesiveness and future effectiveness.				
2	Identifies and acknowledges conflict and stays engaged with it.				
1	Redirecting focus toward common ground, toward task at hand (away from conflict).				
0	Passively accepts alternate viewpoints/ideas/opinions. Doesn't accept confict solving				

3. Discussion and Conclusions

During the academic year 2013/2014, the study module has been being taught using the aforementioned structured PBL approach. A total of 51 students participated. Student attitudes and perceptions to this assessment approach were surveyed through the rubric shown in Table 1. At the end of the semester, every team member filled the rubric evaluating himself and the rest of members. Distribution of respective values for the 13 teams is presented in Figure 1.

Concerning question 1, contribution teamwork, the average score for the whole set of teams is 2.30, with a standard deviation of 0.36 (the highest one in the rubric). Minimum scoring is 1.94 for team 2, while maximum is 2.63 for teams 5 and 6. That mean, that, at average, the members contribute fairly to the teamwork, but with some exceptions. With respect to individuals, only two students received a score of 1.0 in this category, which means a poor contribution for only 2 students from a set of 51. On the counterpart, 7 students received the maximum score of 3.0.

Related to question 2, taking responsibility, the average score for the full group is 2.49, with standard deviation of 0.24. All the teams performed over 2.00, and the maximum is 2.81. Then, students were

responsible in a very god manner in all the teams. Eight students received the maximum score 3.0, while the lowest was 1.5 for one student.

Question 3 referred to individual contribution outside team meetings, it is to say, homework. Average value for this question is the lowest one of the rubric, 2.29, standard deviation being 0.25. Though it is not a bad value, it shows the weakest feature of teams. Seven students received the maximum 3.0 in this category, each belonging to different teams. It seems these students made an extra contribution to teamwork with respect their colleagues. In the opposite, one student scored 1.3, three scored 1.5 and another 1.8, showing also this lazy behaviour at the same time. Only one team got an average of 2.88, very good performance in this category.

Question 4 deals with promotion of constructive team climate. This question obtained an average valuation of 2.52 (the highest of the rubric) and a standard deviation of 0.15 (the lowest of the rubric). It means that high level performance of the teams in this topic, with very high agreement. All the teams performed better than 2.3, with the exception of team 13, which got 1.8. This team seem to have had not a good team climate, scoring of its member ranging from 1.5 to 2.0. In the opposite, two teams had three members with 3.0 and the last 2.5, which shows also high performance in this category.

Figure 1. Average and standard deviation of answers to questions 1 to 5 for every team.
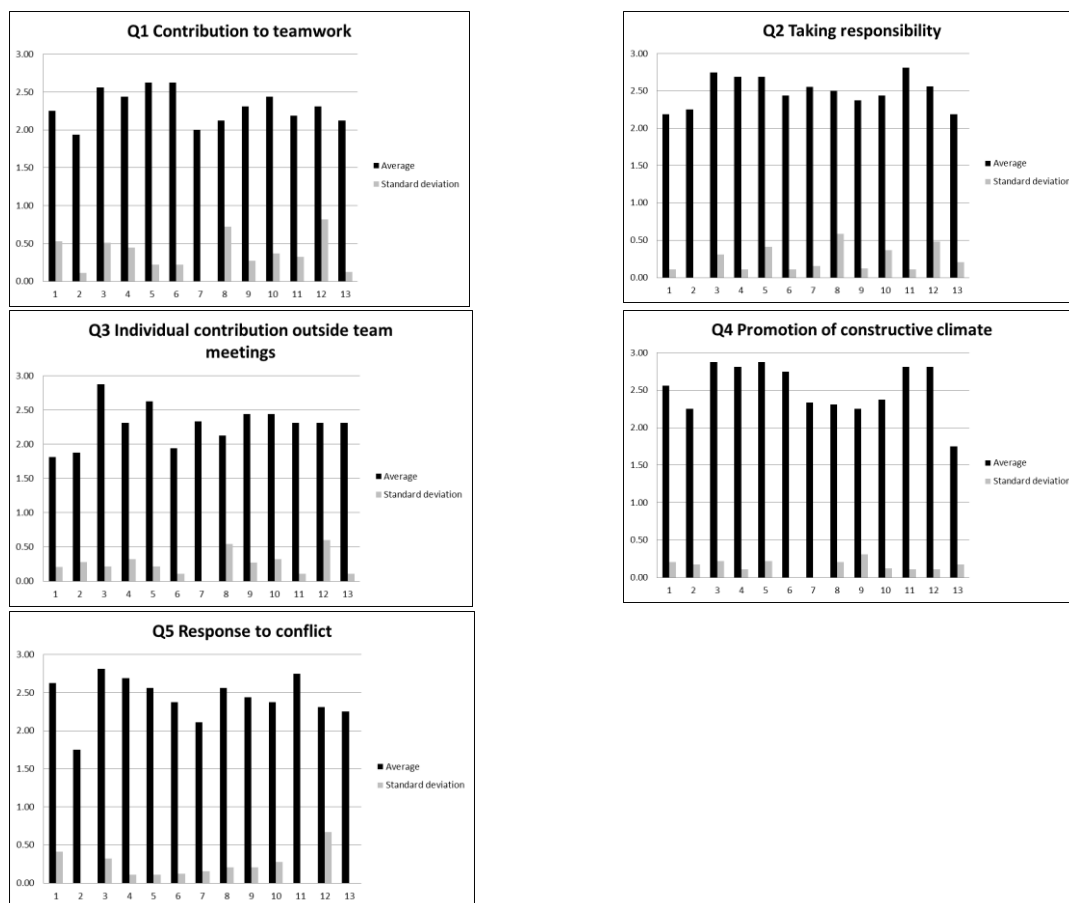
Response to conflict was the topic of question 5. The average value is 2.43, with standard deviation 0.20 (good agreement), showing a fair ability to solve internal conflicts. Maximum value was 2.8 (two

teams), while the lowest was 1.8. Six students received the maximum 3.0, while three of them were in the same team. Only one student got 1.3.

Team 2 got the best scoring in almost all the five categories, average 2.78, with standard deviation 0.31. Categories values range from 2.6 to 2.9, which demonstrate high performance in teamwork skill.

We can conclude that students got a fair performance on teamwork competence. Global average (involving all students and categories) is 2.41, standard deviation 0.20. The students declared the best performance concerning the promotion of good team climate, probably due to the fact that they can work also in teams in other subjects within the study plan, presenting no dramatic interpersonal conflicts. The weakest performance is clearly the contribution of homework. Many reasons could influence this performance, as interest in the topic, or competition with homework of other subjects. With respect to the utility and easy-of-use of the rubric, students show no query about it, all students fulfilled it. It took no more than 4 minutes to keep it. Teacher's perception is that results cover sufficiently the scope of the competence as defined by the institution, and that no more complexity is needed to measure this critical skill.

Acknowledgement

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