Cooperative Learning Strategy in the Improvement of an Electrical Power System Course

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Abstract **- Students must be able to compare and analyze in order to understand the electric power system security problem. The Cooperative Learning method helps students to deal with the complexity of an electric power network. This approach benefits the motivation to learn and the students' self-esteem. Cooperative Learning is seen to improve the classroom environment. Applying this model it is expected that students develop positive interdependence, individual accountability, face-to-face promotive interaction, appropriate use of collaborative skills as well as group processing. Cooperative Learning defines a dynamic process where the students work in teams accomplishing a common goal. The students were divided into teams of four at the beginning of the semester. The materials were divided into four topics so that each student gets part of the information needed to complete the proposed task. Each team member was assigned a different role and was given different resources. The project was evaluated in the group with the students preparing a final report and presenting it to the teachers. The expected benefits were obtained in the evaluation of the unit.**

Index Terms - Contingencies analysis, Cooperative learning, Electric power systems, Security analysis.

INTRODUCTION

In the classical lecturing method students are solo players. They have a less pro-active attitude. They are also much more involved with their individual achievement and much less involved in developing skills such as (team work, leadership) that can be an asset in their future work [1].

The Cooperative Learning (CL) method differs substantially from the classical lecturing. The former represents a new paradigm of teaching with many advantages that can produce a great improvement in the learning process. Cooperative Learning defines a dynamic process where the students work in teams accomplishing a common goal. The team can continue working together for the duration of a project or for a whole semester [2], [3]. The objective of the Cooperative Learning approach is also to reduce the competitiveness and stress of a final exam evaluation while enabling students to develop the much needed cooperation skills. Students actually gain hands-on experience on a project. This method implies that both students and lecturers are involved throughout the whole process. There's also a considerable work load for the lecturers as well as for the students at the initial stage.

The method was tested with students already attending polytechnic level studies in the fourth year programme of Electrical Engineering and the subject was Electric Power Systems Analysis. Security analysis plays a very important role during the planning and operation stages of a power network. The importance of an uninterrupted electric power supply makes the study of power system security in real-time a very demanding and important operation task. A set of security analysis functions is usually developed to help the operator monitor and control the security of the electric power system. These functions involve assessing the security level of the variables obtained from outage studies and control to raise the security level of the system. Steady-state security analysis is defined as the ability of the system to reach a state within the specified secure domain following a contingency impact on the system operation [4]. The main issues in security assessment are the prompt identification of the set of critical or potential critical contingencies and their evaluation related to the severity level [5]. Various large-scale software packages such as the PowerWorld program are widely used [6]. To fulfil this purpose CL will be used as a means to increase student learning in project assignments on power system analysis. CL can be used successfully to help students deal with the complexity of an electric power network.

The students were divided into teams of four at the beginning of the semester. The students' responses to a survey on their preferences were analysed in order to help the instructors organise the teams thus ensuring diversity [1]. The same project was assigned to every team. Positive interdependency is promoted with topics being divided into four parts so that each student gets part of the information needed to complete the proposed task. Individual accountability is enforced on each team member, who is assigned a different role and given different resources. Face-to-face interaction is also applied to the teams; during the process each student will study his/her part of the topic that will later on help to compose the final project. As the final evaluation will be on the whole subject, there must be a constant feedback of information to update all the team members on the whole subject matter. The

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assessment of the true benefits obtained with this procedure cannot be achieved in one semester. It will have to be a process in evolution that can be put to use in successive semesters.

COURSE SYLLABUS

The area of Electric Power Systems has become quite demanding in terms of technological innovation and is closely linked with many other areas of engineering. On the other hand, the industry sector demands much more from their expert technicians in terms of team work competence, designer skills and self-learning capacities/abilities.

The subject in discussion was the project in Electric Power Systems Analysis (Análise de Sistemas Eléctricos I, ASE I) of the fourth year course in Electrical Engineering. The aim of the project was the study and analysis of the Security in an Electrical Power System. Due to economic and environmental constraints electric, utilities are forced to operate their power networks close to the capacity limits or in overload conditions. Security analysis plays a very important role during the design, planning and operation stages.

The software package PowerWorld 11.0 was used to achieve the objectives of this project, [6]. Among other things, it allows the simulation of a power flow and security analysis in Electrical Power Systems. In a first stage, a Tests Power Network with 6 busbar was used followed by a second stage where a wider dimension network was applied. Had the option been to implement one of the contingency analysis methods, such as "bounding method", the network would have used the 6 busbar Test Power Network.

Along the project the students had to do research work on the Study and Analysis of Security in Electric Power Systems; Security Studies in the Portuguese Electric Power Network; Comparison of the criteria used by European and American organisations and also on Severity indices. Extensive research work was needed to study the analysis of the *n*-1 security criterion for a specific load level using the contingency analysis of the PowerWorld 11.0 computing programs package.

The contingencies were classified and ranked using the severity indices to evaluate the impact of overloads in the transmissions' lines and transformers, and the generator units as well as the violation of tension limits in the busbars of the system. In this study two different sets of security indices were used. In the first set the power and the voltage severity indices were used. The power severity indices were applied to evaluate the overload impact in the network devices. The voltage performance severity indices characterize emergency operating conditions where voltage limit violations may occur. The security performance indices of the second set are based on the power losses [4], [5], [7], [8]. The screening and ranking of the contingencies is constructed from composites indices obtained through the severity indices and can be obtained in two different ways. Evaluating the average or weighting the individual indices [9]. Finally, some conclusions were pointed out that provided a valuable contribution to the understanding of the electric power system security analysis. The use of the sets of severity indices led to the changes in the ranking and classification of the contingencies as the methodology allows the easy measurement of control in the security range of an electrical power system.

COOPERATIVE LEARNING

Because of the different knowledge skills of the students entering this type of project, it was decided to carry out the project using the CL approach so that students could work together to maximize their own and each others' learning. The CL approach applied to engineering has improved the way students are facing their learning activity; they are more motivated, learn better and this reflects itself in the classroom environment [2], [3].

The experiment was conducted in the subject (ASE I) of the fourth year course in Electrical Engineering using cooperative learning with structured tasks. The techniques used in ASE I are in conformity with CL. The intention of this learning method is to foster team work in specific well structured learning tasks using five criteria [1], [2], [3], [10]:

1. Positive interdependency. It means that team members have to rely on each other to reach the proposed objective.
2. Individual accountability. The team members are held accountable for their share of the work while supervising the whole project.
3. Face-to-face promotive interaction. The team members will have to perform part or all of the tasks together. It is not acceptable to have each team member solving problems alone and only to find a collective answer in the end.
4. Adequate use of interpersonal skills. Team members will have to learn to deal with issues such as handling conflicts, decision making, communicating, leadership, efficient time management, etc;
5. Regular self evaluation of team work. Students should be able to ask themselves questions such as: 'Are we doing well or is there room for improvement? What should be done differently next time?'

These are some of the advantages of this method: easier relationship among students; better student-student relationship and acquisition of information; high level analysis proficiency; learning motivation; team work and interpersonal competence; communication competence; environment awareness; boost of self-esteem and lower anxiety levels; sounder competitiveness and generator of relationships. With this method the students acquire and put to practise the necessary qualities for excellent team work. Students achieve positive interdependency when each member of the team realizes that s/he cannot achieve anything without interacting with the rest of the team. Students need to be held accountable individually for the part of the work for which they have been allocated responsibility. They should also be individually accountable for learning everything that the team learns. Face-to-face interaction happens when they support and interact with one another. Self-evaluation involves the students in being aware of how they are performing as a team and monitoring their own interaction and progress. Each student within a

team has a piece of the information to be learned by all students, and each one is responsible for teaching their section to the other members of the team [11], [12].

To implement this CL method the students were divided in teams of four from the beginning of the semester. A short survey was handed out in order to build the profile of the individuals and help form the teams. These were selected by the teacher to ensure a wider diversity within each group [1]. Each group was then prepared to work together as a team. The same assignment was given to all teams. The materials were divided into four parts so that each student got part of the information needed to complete the proposed task.

Each team member was assigned a different role and was given different resources. The suggestions were: a Coordinator. S/he had to subdivide the tasks, assign responsibilities, maintain the pace of the work and check the good quality of the performance. The Coordinator also had to produce a short report explaining how the work was divided and the criteria used to assign them to the different team members. This way each student could concentrate on a part of the material without worrying about having to understand the rest of the material. Each team has three students, with special tasks in the team: the Checker, the Recorder and the Sceptic. The Checker had to monitor not only the solution but also its understanding by the whole team. Although each student is given only a part of the work, s/he will be evaluated on the whole subject. The Recorder, s/he had to check if there was consensus and had to write the team's final version. The Sceptic provided alternative suggestions keeping the team from jumping to premature solutions [2].

Positive interdependency is involved in this type of project. The software package PowerWorld 11.0 was necessary to allow the simulation of Power flow in electrical networks. The study of power severity indices were also required to evaluate the overload impact in the network devices. Knowledge of contingency analysis methods was required to implement the project.

The individual accountability is also there because, if one of the students has to know and dominate the PowerWorld 11.0, another one has to be able to give the proper power severity indices, while another one has to study and analyse the security in the Electric Power Systems and apply the contingency analysis method correctly. All this information needs to interact to give a correct solution.

Face-to-face interaction exists when team members interact with their peers or members of the other teams. A student learns his/her part of the material and is then responsible for teaching it to the rest of the members of his/her team. Each team member is expected to become an expert in his/her part of the subject. To achieve it, they regroup and work with the members of the other teams who have been assigned the same task. They work together to work out and clarify issues on the subtopic involved. After that they return to their own team and teach the others how to perform their part of that subject. Interpersonal skills are very important for the success of the project because the subtopic each team member learns is independent but needs to interact with others throughout the project.

Throughout the project, constant cooperation and (re)evaluation is needed to ensure the project is well-designed. The final product will affect the whole team as the students are assessed as a group [12]. Team learning has the additional advantage of focusing the work and the attention around the students and not on the teacher.

The positive interdependence was fostered enabling all the team members to feel they had a unique job to perform within the group, and that the work would only be successful if all its members delivered correctly [11]. Thus, a sole final product was required from each group. Lastly, one student from each team was selected at random to explain (orally or in writing) not only the results but also the method used by them and the final evaluation was given to all members of the same team based on his/her performance.

The above mentioned random selection of the team member to present and explain the results of the group was used to foster individual responsibility. Self-evaluation of the team's performance was conducted on a regular basis. After the first project was over, it was necessary to debate the queries and difficulties of the performance and what should be done in individual and collective terms to ensure a smooth process of a future project. These conclusions were delivered with the final report. The project was evaluated in the group with the students preparing a final report and presenting it to the teacher. Further evaluation of the students was done through tests.

STUDENTS ASSESSMENT

The assessment of this method includes surveys of the students' opinions on working in groups conducted at the end of the semester. The survey referred to the degree of satisfaction using the team work project and the benefits of team project in developing a research work project. The answers were rated from 0 to 5 points scale with 0 indicating poor and 5 representing excellent [10]. As we can see in Figure 1 a great majority of the students enjoyed working with this kind of methodology of group work. 75% of the students agreed with it.

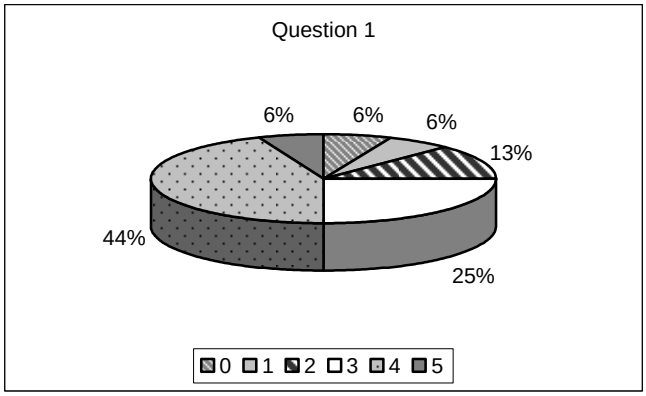

FIGURE 1.
'DID YOU ENJOY WORKING IN A TEAM PROJECT IN THIS PARTICULAR COURSE?'

Figure 2 show that most of the students felt that the team project helped them to learn better how to perform a

research work project. 68% of the students agreed with the method.

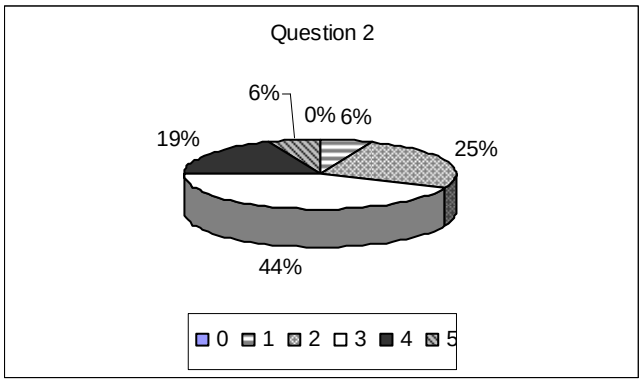

FIGURE 2
'IN WHAT WAY WAS TEAM PROJECT BENEFICIAL IN DEVELOPING A RESEARCH WORK PROJECT?'

In addition, as we can see in Figure 3, there has been a general improvement. The classification system uses a 20 point grading scale wherein 20 is the highest grade and 0 is the lowest. It is required to have at least 10 points to be approved in the course. If we look at the percentages between the scholar years of 2003/04 and 2006/07, it is noticeable that the final grades have become more evenly distributed. In 2003/04 the peak was 75% of students in the range 10-12. In 2006/07 only 44% were included in the same range. If we look at the intermediate range 13-15, it is also noticeable that the grades have considerably risen to 50% in 2006/07.

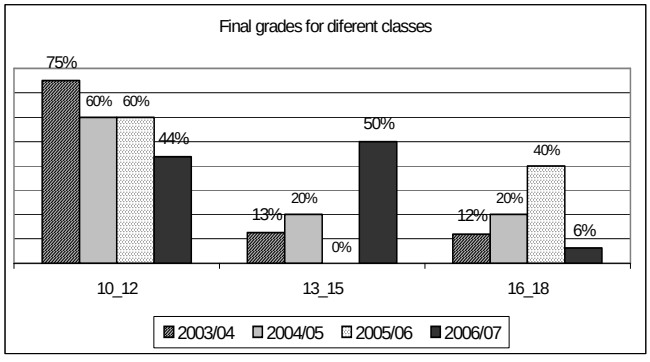

FIGURE 3
FINAL GRADES FOR DIFFERENT CLASSES, IN DIFFERENT YEARS. HORIZONTAL AXIS: SCALE OF RESULTS OF STUDENT EVALUATIONS

The main reason for observing such improvement was the use of CL which motivated a better attitude towards learning compared with the results of students from previous years.

CONCLUSIONS

The students are interested in learning but want to learn in an environment that is both challenging and enjoyable. The results of this experiment show that the CL approach is an excellent method to conduct projects. It is quite an effective process after the paradigm "learning by doing". Of course, there is a much greater involvement, time wise, both from students and the teacher. The students learn to work collectively, which becomes a very important asset as future engineers. CL boosts motivation significantly and raises self-confidence in the student thus becoming an excellent learning experience. The benefits of CL in the Electrical Power Systems course are that they improved the study and analysis of the security in an electrical power system. This method can also be seen as a benefit for Electric Power Systems where educators strive for improved teaching and learning. The evaluation of the true benefits of this method cannot be measured in the span of only one semester. The anticipated benefits were obtained through the teacher's evaluation in the subject matter. It will have to be a process in evolution that can be put to use in successive semesters.
Finally, based on the experience of using this technique for one semester, the authors hope to teach other subjects in engineering courses with this same methodology.

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