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Application management methodologies and group dynamic in technical careers through Jigsaw technique: a case study

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Abstract
The current society and the European Higher Education Area (EHEA) provide several changes in learning methodologies in order to adapt educational system to real world. Taking into account necessities of companies and society, new educational system must increase student participation, as well as cooperative learning. The aim of this paper is to develop a cooperative learning based on Jigsaw technique created by Aronson. This methodology can be used in different academic fields. In this work, the technique is applied in a technical course of Civil Engineering degree at the University of Oviedo. This paper explains the way to apply this methodology to technical degrees. Furthermore, professional skills that students achieve by this technique are identified. These skills are more adapted to current requirements of the companies such as technical knowledge or communication and collaboration within a multidisciplinary group. Finally, paper discussion of the main results and conclusions based on this study are shown.

Keywords
Active learning methods; teaching methodologies; technical degrees, collaborative work, cooperative learning

1. Introduction

Today, companies value more attitudes and skills such as initiative, teamwork and social skills that the academic record of the students. The traditional teaching based on lecture classes cannot enhance these skills, so that it is necessary the use of other teaching methods in which autonomous and cooperative learning takes place.

Also, with the addition of the Treaty of Bologna, the European Higher Education Area objectively values the dedication hours of the student by mean of the ECTS (European Credit Transfer System). This has led to the development of new methodologies adapted to the requirements of the new system and their application in the different studies.

Therefore, the formative objectives have changed. So besides the technical knowledge, the students must acquire other skills such as the ability to teamwork, the analytical capacity and problem solving, the knowledge transfer and the integration in multidisciplinary teams.

The use of work methodologies based on cooperative learning have been widely used in different academic fields (Martinez 2013; Serrano et al 2013), and it is especially useful their application in scientific-technical degrees (Davidson 1990; Rizzo 2006).

Some of the group techniques more employed are:

- Learning teams, STAD, TGT, TAI or CIRC (Slavin 1990).
- Learning together (Johnson et al 1993).
- Co-op Co-op (Kagan 1985).
- Guided or structured cooperation (O'Donnell & Dansereau 1992).
- Research in group (Sharan & Sharan 1994).
- Technical puzzle, JIGSAW (Aronson et al 1978 and 1997).

In all of them, a creative, interactive and cooperative environment is promoted. Besides, the communication and the development of social skills are encouraged. The student must be responsible and tolerant, acquiring autonomy and different roles inside the group. In these conditions he will be able to resolve the raised problems in an autonomous and cooperative way. In the same manner, the professor must encourage and accept the

autonomy and the initiative of the students, by mean of acquiring a mediator and intermediary role, giving resources to the students and encouraging the development of group skills.

In this paper, it shows a practical application of cooperative work. It has been developed in a group of students of Civil Engineer of the Polytechnic School of Mieres (PSM) of the University of Oviedo.

2. Practical framework of the proposed methodology

2.1. Background group

2.1.1. Group features

This is a group of students of the Civil Engineering degree. They are in the third year of the degree and this is the second year of these studies. They have mostly behavior patterns of passivity, assertiveness and little involvement in classroom activities. This requires the implementation of activities that encourage participation and communication, both among students as the professor of the subject. Besides, these activities have to be more suitably adapted to the current demands of the labor market and the European Educational Space.

2.1.2. Skills and learning outcomes

The aim of the students is to reach a general scientific-technical qualification for the development of the profession of Engineer of Public Works. With this objective, they must acquire knowledge about advisory, analysis, design, calculation, project, construction, maintenance, preservation and exploitation, the same way as the capacity to implement the necessary legislation and to plan, supervise and manage work in their field.

The specific skills that are sought are knowledge and understanding of the ecosystem functioning and the environmental factors , of electricity, lighting, water supply and sewage systems in urban and industrial models and their dimensioning, construction and maintenance.

To achieve this qualification, in addition to the lectures classes, there are practical classes and group tutorials in which it is encouraged the consultation of specialist literature available in the library network of the University of Oviedo besides the network resources (legislation, electronic publications, databases, bulletins, and information from national and international associations of urban and environmental nature).

2.2. Objectives

2.2.1. Task to develop

The task to develop in the group tutorials consists of the design of the services of an industrial estate, which include the division of the land (Task 1), the design of the vials (Task 2), the design of the water supply network (Task 3), the design of the sewage network (Task 4), the electrical grid (Task 5), the lighting system (Task 6), the telecommunications network (Task 7) and the presentation and final defense of the proposal (Task 8).

It is a general task, provide the industrial estate with the services. It consists of 8 sub-tasks, of which the subdivision and the vials design are considered key, because if these are not made, it is not possible to start with the rest.

The contents of the tasks to be performed are as follow:

1. **Subdividing the industrial estate**: the students have to draw a map with the location of the industrial estate and the subdivision of spaces on it. In these spaces will be located the industries, the parks, the community centers and the central services (restaurants, hotels, nurseries and banking offices).
2. **Design of vials**: it will be held the design of the road system so as to allow access to all plots. The junctions and the crossovers with the outside, inside vials, parking and pedestrian precinct will be included.
3. **Design of the supply network**: pipeline, piping and necessary elements will be designed to carry out the transfer and distribution of water from the point of supply to the point of consumption.

4. **Design of the sewage network**: the set of pipes and other devices used will be designed to convey wastewater to the public sewer system, or to a particular installation of water treatment and drainage system that leads the white or rain water to places where its use is organized.

5. **Design of the electrical network**: it will be designed the High Voltage Distribution network (HV) for networks with a voltage greater than 1 kV and the Low Voltage Distribution network (LV) for networks with a voltage from 0 to 1 kV in alternating current and from 0 to 1.5 kV in direct current.

6. **Design of the lighting system**: network of public lighting will be done through the design of a lighting system that offers maximum safety, both the traffic and the pedestrians.

7. **Design of the telecommunications network**: it will be designed the set of necessary pipes to accommodate the communications system that will provide service to all plots of the industrial estate.

8. **Presentation and defense of the entire task**: a formal presentation about the services of the industrial estate will take place to the other students.

Table 1. Tasks of the services design of an industrial estate.

TASKS				
1. Subdivision				
2. Vials				
3. Supply network				
4. Sewage network				
5. Electrical network				
6. Lighting system				
7. Telecommunications network				
8. Presentation and defense				

Common tasks to be performed by all group members

Individual tasks

Source: Álvarez Rabanal et al.

2.2.2. Specification of the objectives of the task

Each of the groups will have to consult specialist literature and applicable legislation related to the academic work as well as draw the maps of the subdivision of the land, vials, water supply networks, sewage network, electric network, lighting system, and the tele-communications network of the industrial estate.

The work should be included in a report showing a reasoned each of the decisions made in the design of the industrial estate

Finally, each group will have to make a presentation and defense of its proposal in competition with other student groups.

3. Proposed methodology: integration of Jigsaw teaching method

3.1. Determination of the groupal technique employed

Based on the different groupal techniques most commonly used, the puzzle (Jigsaw) technique developed by Aronson is considered the most appropriate due to its ability to create groups or panels of experts that allow interaction between members of different groups, thus promoting learning of the other companions. This technique raises the positive interdependence so that all members feel that the success of the group depends on the sum of individual actions of each one of them (Pérez Samaniego et al 2010).

This will be an enrichment of both the acquired knowledge as the ability of students to work in interdisciplinary groups and specific topics.

3.2. Description of the technique

The puzzle technique or Jigsaw was developed by Aronson in order to increase student achievement and improving interracial relations (Aronson et al 1978). The results showed an improvement in academic performance due to perceive the other colleagues as sources of learning, reducing competitiveness and increasing the capacity of students to develop work both individually and in groups.

This technique involves the creation of work teams or groups puzzle, in which each team member is responsible for one of the tasks. In this way, students become "experts" in these tasks, so that each member has a part of the information and among all members of the team have full information. The novelty of this methodology is that it allows interaction between different groups through the formation of “expert panels”. In these panels, the experts in each particular subject are meet to discuss and prepare the information that will share with the original group. In this way all the members have the same acquired knowledge.

With this methodology the learning process is structured so that individual competitiveness is incompatible with the success, which can only be achieved through cooperative work.

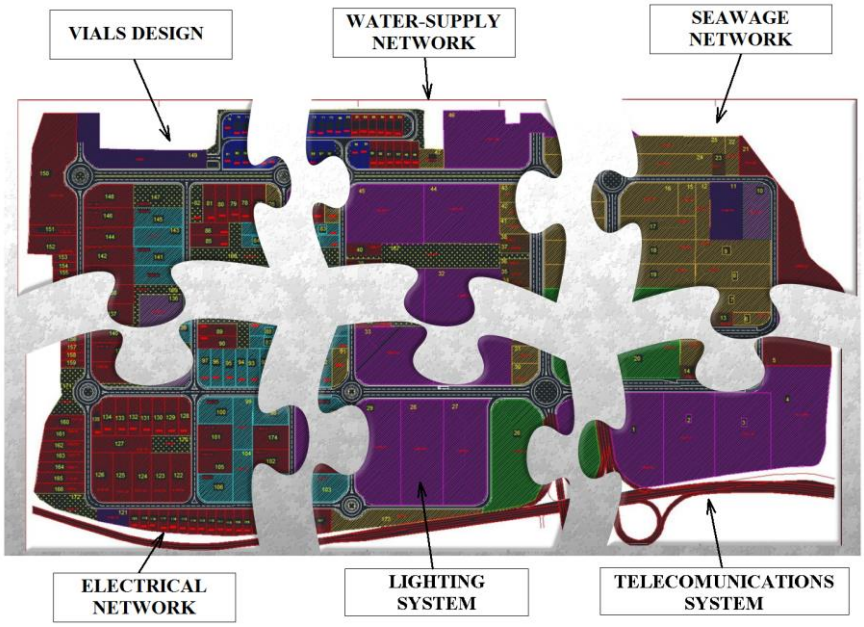

Figure 1. Jigsaw technique: expert panels.

3.3. The groups

Groups are composed of six students although the number of tasks is eight. The first task, division of the land as well as the last one, presentation and final defense of the proposal must be developed by all members of the group. Each member of the group also have one of the other tasks assigned where they will be “the experts”. Knowledge will be transferred between experts from several groups. The experts of each task compose “expert panels” where the knowledge is transferred and the responsibility is improved.

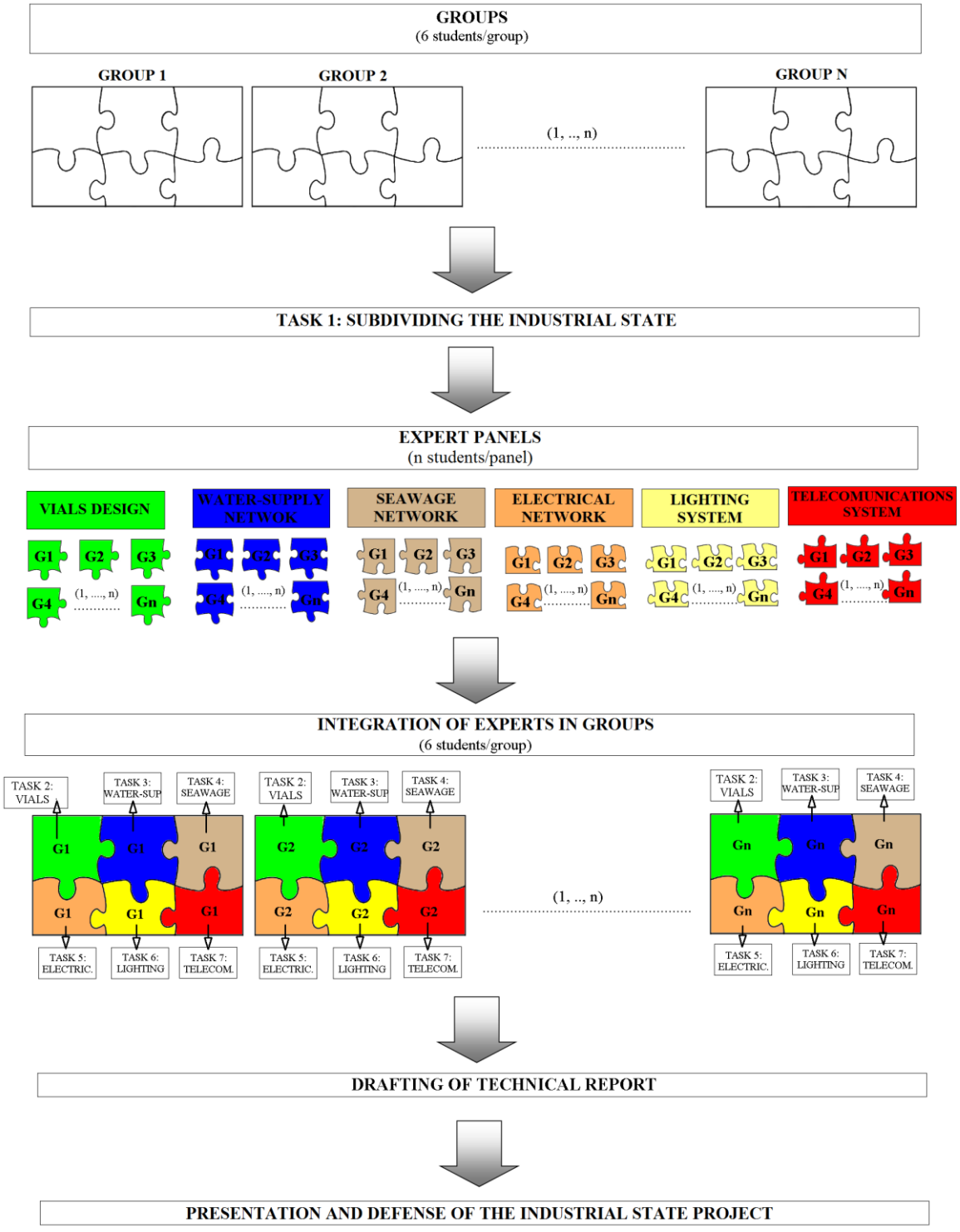

Figure 2. Flow diagram of the industrial estate urbanization.

3.3.1. Assignment of students to the groups

Jigsaw technique encourages both individual and team work by means of "the experts". Beside of this, this technique allow to choose the members of each group by the own students based on their personality criterion.

3.3.2. Role assignments

Each group must have a student who organizes and coordinates the group tasks. Furthermore, this student designates the task for the other students as well as the coordination to work in the technical report.

Professor must help the students to learn. He must give them materials to work with and the structure of the procedures that students must follow. Moreover, professor must help to define tasks and provide to the students resources to work. Professor determines the time needed for each task as well as the meetings schedule and deadlines. Professor is also mediator for conflictive situations such as students who want to dominate, students who do not want to work or marginal students. Finally, professor has to explain to students the evaluation criteria.

3.4. Description of didactic material and available resources

CAD software is available in laboratories for students. They can use computers of the school to draw the plans. They also have available the RETI software to calculate water supply networks as well as the INDALUX software for lighting system design. Students also have available a private room with projector for group meetings and practice the final presentation. Furthermore, students have detailed instructions, standards and references to take into account in this work.

"Virtual Campus" is the Moodle tool at the University of Oviedo where students load their works. With this tool, professors can follow work and activities of students. This system allow the evaluation and communications between students and professor during the entire course.

3.5. Learning evaluation

Professor coordinates and evaluates the cooperative learning of students in weekly meetings when skills can be analyzed: student's implication and participation, projects evolution, deviations from target as well as improvement and solution proposal.

At the end of the work, learning evaluation of the team was based on the quality of the industrial estate urbanization presented (plans, technical report and presentation). Besides of this, each student has an individual correction taking into account their individual learning acquired in the tasks (vials design, design of the water supply network, design of the sewage network, the electrical grid, the lighting system and the telecommunications network)

4. Discussion of proposal and results

Results of this methodology were analyzed using evaluations from professor and anonymous surveys between students.

At the beginning of the work, this methodology provided positive attitude in students and generate extra motivation in this subject. However, some students thought this work was extra effort.

There were some problems between students from same group, however most of them were solved by the own students. There were a very few times when professor had to help them clarify rules, roles and responsibilities.

In summary, this learning process provides an equivalent assignment of individual work along the whole course. Students are more implicated in technical tasks besides of working in a teamwork where final results depends on results of their individual works. In this way, students feel like experts and indispensables for their teamworks. For this reason, they are more implicated in the project and the acquired knowledge level is increased with the use of this methodology. It has also been noted that technical quality of projects was higher than obtained in previous years.

In terms of technical knowledge, the competencies acquired by students get achieve the goals of the subject.

Students have a positive opinion of the work presentation because they can practice a formal defense of their work before their presentation of Degree Project.

5. Conclusions

In this work, a cooperative learning method have been designed, implemented and evaluated in order to achieve some of the objectives marked in the European Higher Education Area (UK-HE Europe Unit Guide to the Bologna Process 2007).

The task designed and the objectives proposed comprise a large part of general skills that are searched in the course: knowledge of functions of analysis, design, calculation, construction, capacity to implement the necessary legislation and project works in this field. Furthermore, knowledge and understanding of the functioning of electrical networks, lighting systems, water supply and sewage networks in industrial design and their sizing and construction are specific objectives also achieved.

The assignment of roles has been adequate in spite of some conflicts generated. Related to this, professors will assess the possibility of forming future cooperative learning groups based on personological criteria.

It has been demonstrated that group technique used and assignation of the panel of experts to certain subtasks promote both group and individual work. Thus, the professor can make a fair assessment of student work and promote intergroup communication. This experience has certainly affected the enrichment of knowledge both individually and groupal.

Finally, from professors' point of view, the application of the Jigsaw technique has been a very positive experience. Methodology used in this work is considered suitable to other subjects and technical grades.

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