

A COMPETITIVE-GAME PROJECT-BASED LEARNING SCHEME FOR MOBILE COMMUNICATIONS SUBJECTS

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Abstract: This paper presents a project-based learning experience to teach mobile communications subjects, carried out at Universidad de Alcalá, Madrid, Spain. The experience consists of a competition among teams formed by students, who act as consultant companies working for imaginary operators. The objective of the teams is to obtain the best network design and economical budget for the imaginary operator in the city of Alcalá de Henares. The proposed learning scheme uses existing concepts of different fields, such as the project-based or the competitive games methodologies, and applies them in the teaching of telecommunications subjects. Details on the practical application of the methodology and the results obtained in Universidad de Alcalá are discussed in the paper.

1 INTRODUCTION

Mobile telecommunications have become a relevant issue in our society. From the social point of view, the mobile is the easiest way to access to the communications technology. From the global economics point of view, the mobile telecommunication market is becoming of higher relevance in the global economy of the nations. As an example the contribution of the mobile market to the UK economy the 2.2% in 2003, more than three times the average, and the forecast is that it will increase up to 7.5% in 2013 (JCL report, 2004).

Following this trend, almost all technical schools and universities in the world offer courses about mobile telecommunications (Cassara, 2006). Specifically, the majority of universities where electrical engineering is taught, offer basic courses about the GSM system, that is also known as 2nd Generation Mobile, previously to other courses about the 3rd generation mobile communications. The teaching of the GSM system in technical schools is usually done in two steps: First, the students receive theoretical classes about how the system works, with details of all its components. In a second step, the students must have the possibility of taking some laboratory work about the GSM system.

In this paper we describe an experience carried out in Universidad de Alcalá, Madrid, Spain, in which a project-based learning scheme (Shankar et al. 2000)

was used to teach part of a mobile communications graduate subject. After a first stage in which the basic theoretical notions of the GSM architecture are explained, we organized the project-based learning by dividing the students of the subject in groups of 3 to 6 people. Each group represents a Consulting firm, with the corresponding team leader. The work consists of performing a full technical and economical study in a specific city for a virtual operator, with its specific economic and technical features. This work is planned as realistic as possible, and then it is like a competition between all teams in such a way that the best project will obtain the best qualification. The evaluation is done considering the technical quality of the solution, the presentation (how the team is able to show the goodness of its study) and the efficiency, in terms of network investment and consulting budgets. In this paper we give details of this project-based learning implementation, as well as the results obtained after its application in a subject of the Telecommunications Engineering degree at Universidad de Alcalá (UAH), Spain.

2 DESCRIPTION OF THE PROJECT-BASED METHODOLOGY PROPOSED

In the real world, the most part of network deployments are done in GSM and UMTS systems, so a

solid formation in these technologies is a must for a telecommunications engineer. On the other hand, our experience tells us that most telecommunication engineers have jobs related with techno-economical studies and/or consulting studies: the majority of engineers work on project management and only a few in *low level* technical issues. This fact made us to prepare a different mobile communication course, with a strong part of the course related to project management. In order to propose such a course, the project-based learning methodology has been considered. In this section we give the basic details of this project-based learning scheme for a mobile communication subject.

The complete course is based into three interrelated blocks.

- A set of theoretical lectures, where the concepts and working of mobile communications are explained.
- A set of lab works where the work teams have to develop some software tools oriented to the mobile network planning.
- The Work Project, that is designed as a real consultancy work.

The qualification of the course is divided into a maximum of 5 points in a theoretical examination and a maximum of 5 points for a consulting project. The main objectives of the project are the following:

- Learning how to work in a real case inside a work team.
- Learning how to assume a specific role and responsibilities in the work team.
- Learning how to manage efficiently scarce resources, specifically time and human effort.
- Learning how to apply the knowledge of the lectures into a real case.
- Learning how to survive into a harsh competitive environment.
- Learning how to present the results of the work (how to sell them to the client).

The project has been structured as follows: the students are divided in several groups with 3 to 6 students. Each group will be treated as a consulting company that will work for an *imaginary* operator. The task of each group will be to perform the complete mobile network deployment in a specific city of Spain, with the corresponding real equipments and to calculate the values of the cost per minute of the different services offered by the operator. In the course 2007/2008, the first year of application of the PBL, the city selected was logically Alcalá the Henares

where the University of Alcalá is located. In the next subsections we detail the complete methodology used to supervise the projects.

2.1 Teams Composition

As has been mentioned before, each group is composed of 3 to 6 students. The selection of the members of the group is done by the students themselves. The students are previously told that smaller groups will have less complicated projects than bigger groups, because in bigger groups can use economies of scale to leverage the work of the project.

Each group has to select the name of the consulting firm and the corresponding corporative logo. Furthermore they have to establish a template for all the reports they have to produce, in order to give a professional image.

A relevant issue at this point is the figure of the team leader. In the real world the team leader in a consulting project is a senior consultant that obviously has more responsibility than the rest of the project members, but on the other hand, he/she earns more money. In our case, the team leader has the responsibility of the success of the project. If the project ends correctly, the qualification of the team leader will be higher than the rest of team members. Opposite, if the project fails, the team leader will be consequently penalized. We encourage the students with more initiative to be the teams leaders.

2.2 Work Definition

As it is outlined above, each team is commissioned with the mobile network deployment of a virtual operator. The input data given to the team is described below.

- The technologies adopted by the operator, GSM or GSM / UMTS.
- The market share of the operator.
- The bandwidth acquired by the operator in each frequency band, GSM 900 MHz, GSM 1800 MHz, UMTS 2000 MHz.
- The total annual minutes billed by the operator.
- The service briefcase for each technology.

The difficulty level of the work depends on the number of members in each team. We have divided into three categories.

- Small operator. Using only GSM technology with low market power, about 15-20% and with frequency bands not very favorable and limited service briefcase. The network design is simple, but

the profitability is low. Therefore in the conclusions of the report they have to make lot of allegations to the regulatory authorities. This kind of operator will be for small teams with 3 members.

- Medium operator. GSM and UMTS technology with market power about 30% and reasonable frequency bands and service briefcase. It is a comfortable position for the network design but the level of exigency in the profitability results will be very high. For teams with 4 members.
- Large operator. This will be the case of the dominant operator with a very high market power, more than 40%, with a large briefcase and large spectrum due to its economic power. The network design is more difficult but the profitability is ensured due to economy of scale. However in the report they have to defend against possible regulatory intrusions to favor the small operators. For teams with 5 or 6 members.

The results of the project is a final report where the following points must be described:

- A executive summary describing the network design.
- Firm, model, price and description of the commercial equipments used for each network element.
- Location in UTM coordinates of each BTS, BSC and radio ling used in the network design, and graphical representation of the results, in form of the corresponding maps.
- Consultant and network design economic reports.
- Profitability of the proposed solution.
- Diagram with the effort in man/months.
- Conclusions and allegations for the regulatory authorities.

Apart from the final report each team will have to perform a short presentation to the lecturers of the subject and other colleagues, some of them coming from mobile operators such as Vodafone group. The objective of this presentation is to force the students to defend their solution against a “semi-hostile audience”, which represents the client in the real world, and that tries to find any possible error on the design.

2.3 Competition and Collaboration between Teams

A classical problem that arises in these types of project-learning schemes is the reasonable collaboration between all teams, sharing information or splitting tasks. In order to manage this point, we have

established the following: If the work is done correctly, the team will obtain a minimum qualification of 2.5 over 5. However, the best group will obtain 5 points the second best up to a maximum of 4.75 the third up to 4.5 and so on. Therefore we organize the projects as a competition between the different groups in such a way that sharing work or information with other groups could be good or bad depending on the situation. Competition or contests have been reported before as a good methodology in engineering education (Gregson, 1999), (Johnson, 2006).

In addition to competition, we also promote collaboration between teams, but in an organized form: In the real world, consultant companies and operators may work together. There are typical network deployments strategies carried out by mobile network operators in order to optimize their investments. For example, site and infrastructure sharing where two operators use the same constructions or masts, and part of the network and the individual investment is hence reduced. This kind of strategies are allowed in our projects, in such a way that two teams can firm agreements, supervised by the lecturer, to share sites, network or only information. In some cases, a team may ask another about information, and hence pay for it. This payment is regulated by the lecturer and a kind of internal contract is sign between teams with the corresponding supervision. All these agreements have to be reflected in the final report.

The final presentations are also a part of the qualification. The teams representing operators with higher market power start first. Therefore the teams with minor market power may study the strategy of the presentations of other teams and make corrections and innovations on their own presentation. This encourages the imagination and improvisation capacity of the teams' members.

3 PRACTICAL APPLICATION: EVALUATION OF AN EXPERIENCE IN UNIVERSIDAD DE ALCALÁ

The course *Mobile Communications* at Universidad de Alcalá, had 35 students in 2007/2008 academic year. 29 students participated in the project-based learning experience (2 students could not participate due to medical reasons, and other 4 decided to attend September exams to pass the course¹).

¹In the Spanish University there are two chances to pass each course: the first one in February or June exams (depending on the course semester) and then a second one in

These 29 students were grouped into seven teams in the following way:

1. Group 1. Name: **Deivcom**, 6 members.
2. Group 2. Name: **2VZ**, 5 members.
3. Group 3. Name: **Efigenia**, 5 members.
4. Group 4. Name: **Aldama**, 4 members.
5. Group 5. Name, **Konektos**, 5 members.
6. Group 6. Name, **MCommunications**, 4 members
7. Group 7. Name, **CHT**, 3 members.

The ranking of the competition was: 1.- Efigenia, 2.- Deivcom, 3.- Aldama 4.- Konektos, 5.- CHT, 6.- 2VZ and 7.- MCommunications. All teams performed the work satisfactorily and therefore the team leaders obtained the corresponding slight increment in his/her qualification.

Several points can be used to measure the performance of our experience. The first one is the percentage of students that did not attend to the February examinations. Figure 1 shows that in the academic year 2006/2007 this figure was near 30%, however in this year it was less than 10%. This indicates that the students perceive that the course is more interesting with this kind of methodology, so the students work more hours in the subject.

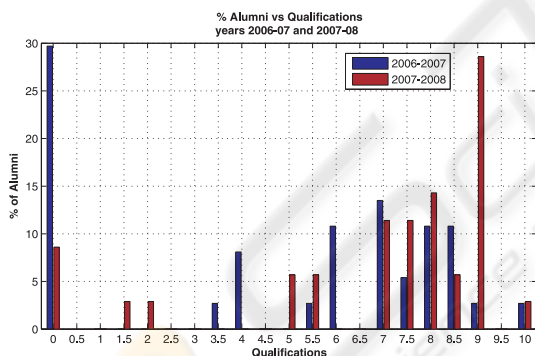


Figure 1: Comparison of marks' histogram for academic years 2006/2007 and 2007/2008 (a value 0 means that the student did not attend to the February exam).

The second indicator is the number of students that did not pass the course (final mark below 5 points out of 10). With the traditional methodology applied in 2006/2007 this percentage were 10.8%, but in this year we have reduced the percentage of students who fail the exam to 5.8%.

The third indicator is the average qualification that has increased from 6.92 to 7.48 (see Table 1). Finally the statistical mode was 9 in year 2007/2008 whereas in the previous year was 7.

September exams.

Table 1: Detailed comparison of marks for academic year 2006/2007 and 2007/2008. DNA stands for the percentage of students who did not attend to the February exam.

Parameter	2006/07	2007/08
DNA (%)	29.7	8.6
Fail(%)	10.8	5.8
Average mark	6.82	7.48
Statistical mode of marks	7	9

4 CONCLUSIONS

This paper presents the application of a project-based learning scheme (PBL) to a course about mobile communications in the 5th year of the Telecommunication Engineering studies at Universidad de Alcalá. The students impression about the methodology is that, in the last years of their degree this kind of projects prepare them better to their professional life, because the type of activities done in the proposed project are closer to the ones done in their future jobs.

REFERENCES

JCL Communications Ltd. (2004). The Changing Economic Impact of Mobile Telephones. July 2004.

F. A. Cassara (2006). Wireless Communications Laboratory. *IEEE Trans. Educ.* 49(1).

P. H. Gregson and T. A. Little (1999). Using contests to teach design to EE juniors. *IEEE Trans. Educ.*, 42(3).

M. C. Johnson and Y. H. Lu (2006). Teaching software engineering through competition and collaboration. In *Proc. of the Amer. Soc. for Eng. Educ, Annual Conference*.

P. M. Shankar and B. A. Eisenstein (2000). Project-Based Instruction in Wireless Communications at the Junior Level. *IEEE Trans. Educ.*, 43(3).