Active Learning in Telecommunication Engineering: A case study

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Abstract—**Bologna process establishes a big change from class-based lessons to active learning. This process shifts the focus from instructor-centered teaching to student-centered active learning, putting the student in the centre of his own learning. This paper presents a case study of active learning in Telecommunication Engineering at Rey Juan Carlos University. Specifically, it presents the experience of different active learning activities in Object Oriented Programming (OOP) subject, where students developed their initiative and critical thinking. This paper presents both global data (i.e. number of students, their background, description of the theoretical, practical and new active learning activities) and specific data (i.e. scores obtained in the different activities proposed, time spent in each learning activity, participation in the learning activities, students' interactions, etc.). Furthermore, the comments of the own students about their personal experience with these new active learning activities are included.**

Keywords: Engineering Education; Collaborative Work; Active Learning.

I. INTRODUCTION

Bologna process establishes a big change from class-based lessons to active learning. This process shifts the focus from instructor-centered teaching to student-centered active learning, putting the student in the centre of his own learning. Lifelong learning has been recognized as an essential element of the European Higher Education Area since the Ministers met in Prague in 2001 [1]. The '*Prague Communiqué*' signals that in a Europe built on a knowledge-based society and economy, lifelong learning strategies are necessary to face the challenges of competitiveness and the use of new technologies, and to improve social cohesion, equal opportunities and quality of life. Since then, there has been growing awareness of the need to embed lifelong learning within higher education.

This new educational paradigm requires other methodologies that enhance the active role of the student, his initiative and critical thinking. There are several pedagogical theories related to active learning such as '*Sociocultural Theory*' or '*Constructivism Theory*'. On the one hand, '*Sociocultural Theory*' [2] emphasizes that the human intelligence originates our society or culture, and that individual cognitive gain mainly occurs through the interaction with the social environment and the knowledge internalization. Knowledge is constructed and discovered by students and transformed into concepts, which students can relate [3]. Learning consists of active participation by the student versus passive acceptance of information presented by an expert lecturer. Students are actively constructing their own individual knowledge, and learn how to understand and appreciate different perspectives through a dialogue with their peers. On the other hand, '*Constructivism Theory*' [4] states that knowledge is not a fixed object but an object continuously evolving. Knowledge is constructed by the individual through his own experience of that object. Learners have to assume the responsibilities related to their own learning. They have to develop abilities to monitor and direct their own learning and performance. When people work collaboratively in an activity, they can see a problem from different perspectives and are able to negotiate, to generate meanings and solutions through shared understanding.

In both pedagogical theories, students collaborate with others in order to promote the active learning and the interaction between peers. The origins of collaboration activities are based on the real world, given that everybody is member of several groups. In our daily activity we are continuously interacting inside groups: in the family life, with our friends, in our work, etc. Our personal identity stems from the way of perceiving and of treating with other members of the groups. Within the group we learn to behave, to think, to educate ourselves and to learn from our interaction with the rest of the members of the group [5].

There are several research works performed at different fields that they evidence the goodness and the limits of active learning. In [6], it is found that there is broad but uneven support for the core elements of active, collaborative, cooperative and problem-based learning. This paper also shows that a unique technique is inadequate to achieve a better learning. Felder et al. [7] give some instructional methods to support these new paradigms, in order to teach more about "real-world" engineering design and operations.

Face-to-face collaborative learning has been applied in traditional classrooms since the 70s, although most of theoretical studies related with it date back of the 80s [8]. In these years different methods and studies arose trying to apply collaborative learning technologies to students of diverse ages

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and levels. These experiences pointed out that the learning process is not only the own identification of the knowledge finally acquired, but also includes the explanations that are provided in order to identify which information is missed, the inconsistencies that are detected, what needs to be clarified or is discussed from different points of view by different members of the group [2].

In this one sense, collaborative learning is a social activity that involves a students' community in which some knowledge is shared and other new one is acquired (knowledge construction) [4] [9]. It means that, apart from the solution itself, it is also important the process that has made it possible to reach that solution. Then, the goal of collaborative learning is that the students were actively involved in the exploratory learning process working together [10].

Collaboration has great benefits such as to promote the cooperation, the interaction and the familiarity among students and teachers. Moreover, from the computer scientists' point of view, collaborative environments facilitate the development of reasoning skills [11] such as making ideas explicit, arguing, interacting with other students to build a common solution, and so on [12]. There are some experiences that demonstrate that the student's motivation, participation and auto esteem increase when they obtain good results in the accomplished collaborative activities.

Also, there is another fact that has to be taken into, and has to with the huge number of students that have difficulties to express their opinions in public. In traditional classrooms when the teacher asks to one student, the focus of the attention is centered in him or her, while in collaborative environments the focus of attention is distributed among the members of a group. Therefore, collaborative learning creates a safe environment in which students can express and explore their own ideas without fear to failure or critics, helping to develop their skills of communication. The student companions can make constructive critics to the different ideas that are proposed [13], while the teacher can evaluate the learning process as a whole (the reasoning process), not only the final solution of the activity. In this sense, some studies on cooperative learning among students of different ethnics state that their communication skills have been clearly increased [8], due to the fact that students have been actively involved in the learning process, being able to understand the differences, and helping them to learn how to solve the social problems that could arise among them.

Collaborative workgroups should be constituted by the minimal number of people need to perform the work in a effective way. Although collaborative learning groups typically are constituted by two to four persons, the basic rule is: 'the smaller the better' [5]. However, there is not an ideal size for collaborative learning group. The group's productivity is determined by how well the members work together. Usually, homogeneous groups can achieve better specific aims, however, when students with different abilities, experiences and interests are combined (heterogeneous groups), they can obtain more advantages than homogeneous groups. In addition, if the students are allowed to organize themselves, they usually create homogeneous groups, and if the teacher is responsible for making up the groups, he or she selects homogeneous or heterogeneous groups according with his/her personal criteria [14].

To sum up, Bologna process motivates a teaching change where the student was the responsible to own learning process in order to promote the lifelong learning. Collaborative learning between peers has been used during years with this purpose. Furthermore, it contributes to development of personal and social skills such as critical thinking, teamwork, communication abilities and conflict resolution between others.

In this new frame, a combination of different individual and collaborative learning activities play an important role in providing new contexts and possibilities in order to develop these skills. This paper presents a case study of active learning in Telecommunication Engineering at Rey Juan Carlos University. Specifically, it presents the experience of active learning in Object Oriented Programming (OOP) subject.

This paper is structured in several sections. Section 2 describes the general characteristics of the case study including a description of the subject and the characteristics of the new active learning activities proposed to students in order to improve their own learning. In section 3, the global results of this case study and the scores of the new learning activities are shown. Finally, conclusions are presented.

II. THE CASE STUDY

Object Oriented Programming is an optional subject at third year of Telecommunication Engineering at Rey Juan Carlos University. This subject is structured in two main parts: principles of Object Oriented Design using UML and, basic concepts of OOP and applications in Java.

Although all the students belong to Telecommunication Engineering, their profile is different. On the one hand, some students have already studied other subject where they have programmed in Java language. They know some aspects of OOP (concepts of class, object, encapsulation, polymorphism, inheritance, etc.). On the other hand, other students have programmed in other structured programming languages but not in Java. These last students have not previous knowledge of Object Oriented Programming. Students of both profiles have not previous knowledge about object oriented design.

In past years, this subject was structured in theoretical and practical sessions. In theoretical classes, the teacher explained concepts, showed examples of the concepts and proposed exercises to students for solving in the classroom. In practical sessions, students developed Java applications in order to put in practice the theoretical concepts. With this model, students were already participated of their own learning process in an active way.

However, during the 2008-2009 academic year, the teachers of this subject thought that could be useful to include learning activities where students develop their initiative and critical thinking and promote the interaction between students with different background. With this goal, some practical exercises related to object oriented design; a collaborative activity with a public oral presentation; and new practical

sessions were proposed to students. Each new activity is explained in the next sub-sections.

A. *PACS ('Programming Assignment Correction System')*

Teachers of OOP subject wanted students would acquire deep knowledge of "object oriented design" topic and participate in an active way on their own learning process. Furthermore, they wanted that students would develop some personal and social skills such as critical thinking and communication abilities.

In this way, the teachers decided to combine theoretical classes with some practical exercises related to object oriented design. The whole 'OO Design' teaching process can be observed in Figure 1.

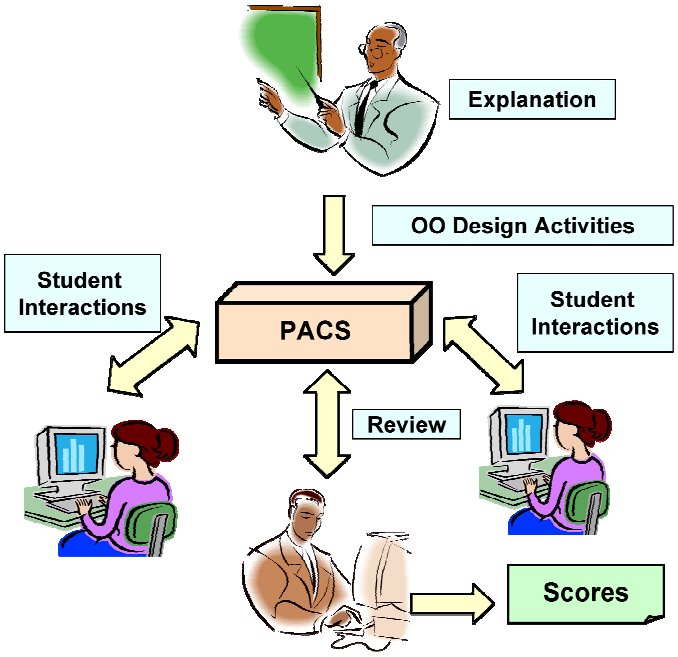


Figure 1. OO Design Teaching Process using PACS.

Firstly, 'Object Oriented Design' concept and the different types of UML diagrams were explained by the teacher in the classroom. Furthermore, students could observe design examples of different OOP applications and accomplish small exercises in the classroom related to every type of UML diagrams.

When theoretical bases had been explained, the teacher proposed a set of practical exercises related to OO design to the students. These exercises should be performed individually by each student. Once students finished their design exercises, they might send their solutions to PACS ('*Programming Assignment Correction System*'). This system is a CSCL ('*Computer Supported Collaborative Learning*') tool developed by Manuel Freire at Universidad Autónoma de Madrid [15]. Students uploaded their solution to this system and then, they adopted the teacher role. They should correct the designs of two classmates corresponding to the same set of exercises or a similar set.

Before using PACS, teachers provide an explanation of this system, how to use it, and a guide with the criteria in order to correct the solutions of their partners. This guide includes the following instructions:

- If the solution of his partner was perfect, the student should try to obtain alternative solution designs in order to give feedback to his partner. Furthermore, he should compare the solution of his partner with his own solution and then, analyze if he did mistakes or if he has misconceptions. If a student would realize he has made errors or he had misconceptions, he should think how to solve them.
- If the solution has mistakes, the student might detect them, explain them and provide solutions.

Furthermore, teachers explained that when they uploaded the correction to the partner solution, they would receive comments about their own correction. The system allows the interaction between students and peer-to-peer collaboration. In this way, if a student is not agreed the correction of their classmates, he could comment their doubts and discuss with them. A student can discuss with his reviewers and with his partners whom he have evaluated their designs.

The figure 2 presents a screenshot with the comments of two students regarding to a certain OO design using PACS. It presents a review accomplished by Víctor and an answer of his partner, María Angeles. They talk about the state diagram of a vending machine. They are discussing the correct solution for this problem. Víctor provides a correction to María Angeles. However, María Angeles is not agreed with some aspects of the Víctor's correction. She comments her doubts arguing the problematic aspects.

An example of a summary with the score given by a student with the teacher role to the solution of his partner is presented in figure 3. The students should assign two scores. The first one indicates if it is possible to improve the solution uploaded. The second score captures if the design of the problem proposed is right or not.

For each student, the final score of this activity is calculated taking into account the own solution of the student (40% of the final score) and the corrections performed to the exercises of his partners (60% of the final score). As it can be seen, the accomplishment of good corrections was considered more important than the own solutions. It was owing to the fact that some students did not take the correction seriously in previous experiences with this system. For this reason, teachers decided to attach more importance to the correction process. The maximum score is obtained when a student has an own good solution to the set of design problems and he corrects the exercises of his classmates in a critical way, as he was the real teacher of the OOP subject (giving feedback such as explanations of the mistakes and possible solutions, or alternative ways to solve the same problem).

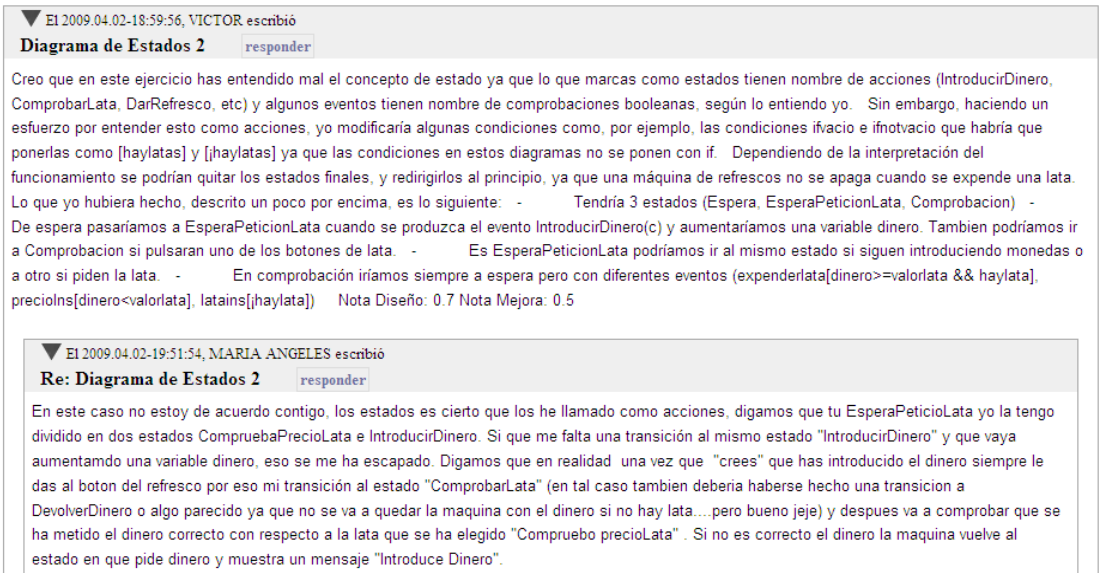

El 2009.04.02-18:59:56, VICTOR escribió

Diagrama de Estados 2 responder

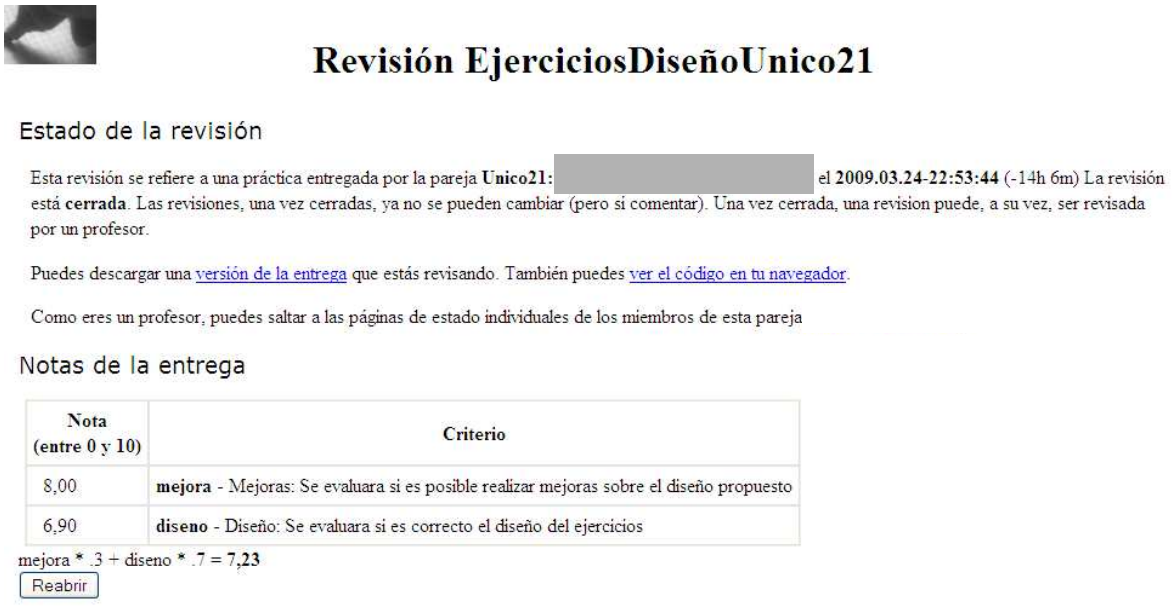
Creo que en este ejercicio has entendido mal el concepto de estado ya que lo que marcas como estados tienen nombre de acciones (IntroducirDinero, ComprobarLata, DarRefresco, etc) y algunos eventos tienen nombre de comprobaciones booleanas, según lo entiendo yo. Sin embargo, haciendo un esfuerzo por entender esto como acciones, yo modificaría algunas condiciones como, por ejemplo, las condiciones ifvacio e ifnotvacio que habría que ponerlas como [haylatas] y [¡haylatas] ya que las condiciones en estos diagramas no se ponen con if. Dependiendo de la interpretación del funcionamiento se podrían quitar los estados finales, y redirigirlos al principio, ya que una máquina de refrescos no se apaga cuando se expende una lata. Lo que yo hubiera hecho, descrito un poco por encima, es lo siguiente: - Tendría 3 estados (Espera, EsperaPeticionLata, Comprobacion) - De espera pasaríamos a EsperaPeticionLata cuando se produzca el evento IntroducirDinero(c) y aumentaríamos una variable dinero. Tambien podríamos ir a Comprobacion si pulsaran uno de los botones de lata. - Es EsperaPeticionLata podríamos ir al mismo estado si siguen introduciendo monedas o a otro si piden la lata. - En comprobación iríamos siempre a espera pero con diferentes eventos (expenderlata[dinero>=valorlata && haylata], precioIns[dinero<valorlata], latains[¡haylata]) Nota Diseño: 0.7 Nota Mejora: 0.5

El 2009.04.02-19:51:54, MARIA ANGELES escribió

Re: Diagrama de Estados 2 responder

En este caso no estoy de acuerdo contigo, los estados es cierto que los he llamado como acciones, digamos que tu EsperaPeticioLata yo la tengo dividido en dos estados CompruebaPrecioLata e IntroducirDinero. Si que me falta una transición al mismo estado "IntroducirDinero" y que vaya aumentamdo una variable dinero, eso se me ha escapado. Digamos que en realidad una vez que "crees" que has introducido el dinero siempre le das al boton del refresco por eso mi transición al estado "ComprobarLata" (en tal caso tambien deberia haberse hecho una transicion a DevolverDinero o algo parecido ya que no se va a quedar la maquina con el dinero si no hay lata....pero bueno jeje) y despues va a comprobar que se ha metido el dinero correcto con respecto a la lata que se ha elegido "Compruebo precioLata" . Si no es correcto el dinero la maquina vuelve al estado en que pide dinero y muestra un mensaje "Introduce Dinero".

Figure 2. Example of the interaction between students using PACS


Revisión EjerciciosDiseñoUnico21

Estado de la revisión

Esta revisión se refiere a una práctica entregada por la pareja **Unico21:** el **2009.03.24-22:53:44** (-14h 6m) La revisión está **cerrada**. Las revisiones, una vez cerradas, ya no se pueden cambiar (pero si comentar). Una vez cerrada, una revision puede, a su vez, ser revisada por un profesor.

Puedes descargar una versión de la entrega que estás revisando. También puedes ver el código en tu navegador.

Como eres un profesor, puedes saltar a las páginas de estado individuales de los miembros de esta pareja

Notas de la entrega

Nota (entre 0 y 10)	Criterio
8,00	**mejora** - Mejoras: Se evaluara si es posible realizar mejoras sobre el diseño propuesto
6,90	**diseno** - Diseño: Se evaluara si es correcto el diseño del ejercicios

mejora * .3 + diseno * .7 = **7,23**

Reabrir

Figure 3. Example of the summary of the review from a student to other

B. Collaborative work and oral public presentation

The main goal of this activity was to promote the collaborative work, the active and autonomous learning and the development of communication skills. This activity was proposed to students at the end of the year. The teachers suggested a list of topics related to theoretical concepts explained before to students in the classroom. Students should organize themselves in workgroups. Then, they should choose a topic from the following list in order to study the topic selected and perform the collaborative work:

a) Relationships between OO design diagrams and their implementation in Java

b) JavaMail

c) Java and mobile devices

d) Distributed Java programming with RMI

e) Java and XML files

f) Database access with Java

g) Servlets and JSP

h) Regular expressions in Java

i) Dates, calendars and formats in Java

j) Creational design pattern: Factory, Singleton

The number of students who constituted the collaborative workgroup depended on the complexity of the topic selected. After students chose the topic, they have to do work on the assigned tasks. Firstly, they should find information of the topic selected, study this information and understand the basic aspects for this topic. Then, they should do a PowerPoint presentation of the work. At least, this presentation should include: i) a brief introduction to the topic selected presenting the general aspects, the most relevant features, advantages, problems, etc; ii) easy examples related to this topic; iii) an exercise for proposing to the rest of the classroom, iv) the solution to the previous exercise, and v) a brief bibliography.

At the end of the year, one person of the group who would be chosen randomly by the teachers would present the work to their classmates.

The score for this activity took into account the contents of the PowerPoint presentation (inclusion of general aspects, descriptive examples, well-structured exercises and correct solution), the design of the presentation (clarity, structured information, etc.), and finally, the oral presentation accomplished (clarity when they were explaining the main ideas, time spent, etc.). All the members of the same workgroup had the same mark taking into account the previous criteria. This activity works the knowledge, the comprehension and the application level of Bloom's taxonomy [16].

Students performed high quality presentations, explained the general aspects for this topic in a clear and concise way. They were able to extract the significant information for each topic selected, to present relevant examples and to propose representative exercises to the rest of their classmates.

C. *New practical programming sessions*

In previous years, students performed practical programming sessions where they practiced the concepts explained in theoretical classes. This year, the practical sessions included new practical programming activities. These activities consisted of learning of two basic concepts: multiple inheritance and exceptions in an autonomous way.

In theoretical classes, students learnt that Java does not allow multiple inheritances, but can be achieved using interfaces. In order to illustrate how to do multiple inheritance in Java, teachers gave a research paper to students. In Spain, it is not usual that the teachers of the degree subjects give research papers to their students. The paper was titled "*Eliminando la herencia múltiple y el diamante de la muerte*" ("*Removing the multiple inheritance and the Death Diamond*"), by Diego Bravo Estrada [17]. It includes interesting reflections about some topics the students were learning. Besides, the paper contains many examples, so they could understand and even compile what the text explains. In fact, the exercise consists of solving the problems proposed in the article. These exercises illustrate a classical problem in multiple inheritance, that is related to topics such as simple inheritance and polymorphism. In the problem, there is a building with some properties and some methods associated. Furthermore, there are a hotel and a restaurant, which extend the building. And finally (what represents the key for the multiple inheritance), the paper proposes the idea of adding a hotel-restaurant to the model, which extends the hotel and also extends the restaurant. The students worked with inheritance and polymorphism. They also thought over the inheritance (simple and multiple), its problems and some possible ways to solve them. Of course, the solution is presented in the own paper, so they could consult if they would want, after having tried to do it. This practice respects their individual rhythm of learning. Furthermore, some questions related with the comprehension of the paper were asked to students. Mixing all, this activity is a full exercise, which works the knowledge, the comprehension and even the application level, talking in Bloom's taxonomy terms [16].

The second new practical session consist of teach the concept "Exceptions in Java" in a really practical way. Firstly, a very brief theoretical explanation was given to students. This explanation consisted basically of linking this concept with the "mistake" concept, and explaining (very briefly) the role that the exceptions play in the hierarchical structure of classes in Java. Then, a simple code related to exceptions was given in order to compile and run it. With this code, they understood why there are different types of exceptions. The code is gradually getting hardest, and new situations related to exceptions appear. At the end, they had seen the most typical scenarios they would find in many programs. This exercise, such as the previous one, is a guided exercise that assumes the students can see the solution when they would believe that it is time to do it. This type of exercises guides to students on their own learning, if they act with responsibility.

III. RESULTS OF THE CASE STUDY

Next, different results of the case study are presented including: i) the final scores obtained by the students of this subject compared to previous academic years, ii) results of the students related to the different learning activities proposed, and iii) data about the participation in the learning activities. The comments of the student experiences with the new active learning activities are included too.

Students of OOP subject at Universidad Rey Juan Carlos have two opportunities to pass the subject in the same year: June and September. During 2008-2009 academic year, there were 26 students in OOP subject. This year, the final score took into account all the activities performed by students and a final exam. Practical sessions, including the new ones, had a weight of 30%; the OO design exercises with PACS and the collaborative work with an oral public presentation were the 10% of the score and finally, the exam was the 60% of the total score.

Table I and II show the scores obtained by students of this subject along three different academic years, between 2006-2007 and 2008-2009 years in both two opportunities: June and September.

Table I presents the scores obtained in June opportunity. The total number of students who chose this subject is stable along these three academic years: 26 students for 2006-2007 and 2008-2009 years, and 25 students during the 2007-2008 year (see the last row in table 1). As it can be shown, the number of students who decide not to present to the final exam (NP row) decreases in the last year opposite to the previous years (only 9 students did not take the final exam against 15

students in other previous years). Furthermore, there are not any students who failed the final exam of June in the last year. These facts cause that the number of students who passed the final exam increased and, the better results rose too in the last year (see the increment of the ">=7 and <9" and ">=9" rows).

TABLE I. SCORES FOR DIFFERENT ACADEMIC YEARS - JUNE

	2006-2007	2007-2008	2008-2009
<5	4	3	0
>=5 and <7	3	5	11
>=7 and <9	2	2	5
>=9	0	0	1
NP	15	15	9
TOTAL	26	25	26

The improvement of the student scores during the last year can be observed in figure 4. The line with rhombus (blue colour) represents the number of students who failed the final exam. The line with squares (pink colour) represents the students who passed the final exam with the minimum knowledge required. The line with triangles (red colour) and the line with crosses (green colour) show the good and excellent student scores respectively at the bottom of the figure 4. Finally, the line with asterisks (purple colour) placed to the top of the figure, shows the number of students who decided not to present to the final exam. This last fact is really important because it means that students had been more motivated this year, and maybe the mix of the new learning activities with the previous ones would have contributed to it.

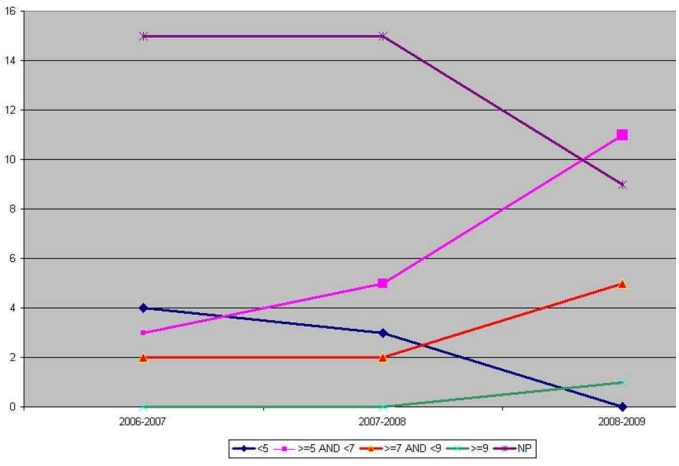


Figure 4. Scores for OOP subject during three years

Table II presents the scores obtained by students during these three academic years in the September opportunity. The number of students who had to present to the final exam in this opportunity were 21 students in the 2006-2007 year, 18 students in the 2007-2008 year and finally, 9 students in the last year. It is important to remark that the last row of this table does not includes the number of students who passed the subject in June opportunity.

TABLE II. SCORES FOR DIFFERENT ACADEMIC YEARS - SEPTEMBER

	2006-2007	2007-2008	2008-2009
<5	1	2	1
>=5 and <7	3	6	1
>=7 and <9	2	0	1
>=9	0	0	1
NP	13	10	5
TOTAL	21	18	9

The total number of students who did not pass OOP subject was 14 in 2006-2007 year, 12 in 2007-2008 year and, 6 in 2008-2009 year (obtained of "<5" and "NP" rows of Table II). We observed that this method achieves a significant decrement of these students. Only the 23% of total students did not pass subject in 2008-2009 year regarding to 54% in 2006-2007 year and 48% in 2007-2008 year. These global results show a clear improvement in the scores of the students and a fall in the number of students who drop out the OOP subject during the last course.

Regarding the results of the OO design exercises and the '*Programming Assignment Correction System*', there were 21 students who participated in this activity against 5 people who did not it. The participation of the students in this subject was high. Figure 5 shows the scores obtained in this new active learning activity by the students.

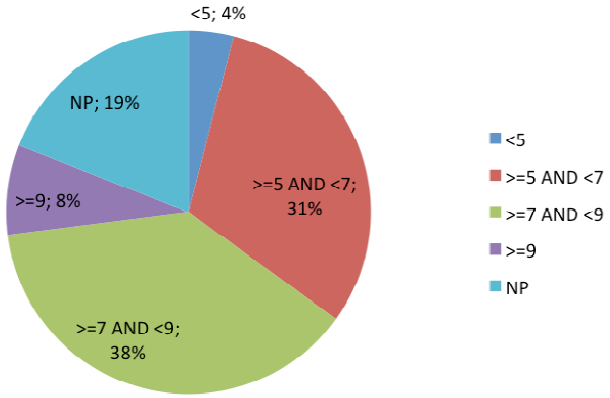


Figure 5. Scores of the students in the OO design exercise

In general, all the students did their exercises and corrected the classmates' exercises appropriately, taking into account the criteria given by the teachers of the subject. Only one person did not take seriously the peer review process of the solution of his partners, and he fails this activity because this is a requirement to obtain the maximum score. Furthermore, students performed better corrections to their partners than their own solutions.

After doing this activity, an opinion poll was done to the students in order to capture the feelings of the students about this type of active learning activity. The peer review process with PACS was easy for the students. They did not need to spend too much time reviewing the exercises of their partners.

This is owing to the fact they have already worked in OO design exercises previously. This type of activity is funnier than other classical learning activities because they can interact with their classmates and helping between them. They like seeing the correction process adopting the teacher role and teaching one another. They understand the comments of their partners in an easy way and they accepted better the critics and comments of their partners. The comments of their partners motivate them and they are a good feedback before obtaining the comments of the teacher.

Students who used Internet Explorer Web browser had some difficulties with PACS when they tried to upload their comments and corrections to the system because this system is optimized for Mozilla Firefox.

Regarding the collaborative work and the oral public presentation, the results were excellent as it can be seen in figure 6. Only three students had not presented this work to the rest of the classroom. Students made presentations whose quality was good or excellent. They explained to their partners the main characteristics of the topic selected and they established the relationships with the concepts explained during previous theoretical classes of the course. Furthermore, they were able to answer the questions performed by their own partners and the teachers. This activity motivates students because they knew new concepts that allow having a global view of more useful topics related with the concepts explained in the course.

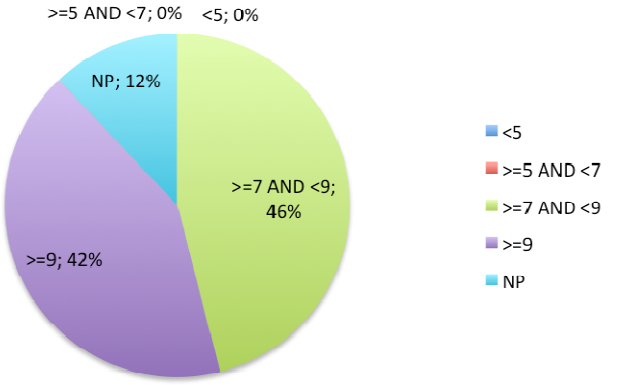


Figure 6. Scores of the students in the collaborative work and presentation

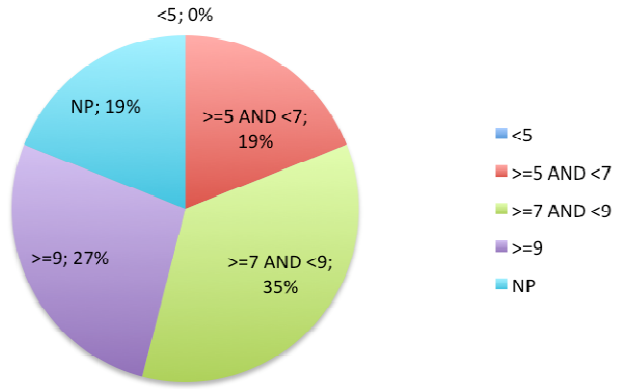


Figure 7. Scores of the students in practical sessions

Finally, the scores obtained by students in the practical sessions are presented in figure 7. As it can be seen, there is nobody who failed the practical sessions. However, there are five students who did not present their practice exercises. In general, scores are really good since 16 students (equals to 62% of the total) obtained a score higher than 7.

IV. CONCLUSIONS

This paper has presented a case study of the experience to include new active learning activities in the Object Oriented Programming (OOP) subject of Telecommunication Engineering at Rey Juan Carlos University. As it can be seen in the results presented of the previous section, the number of the students who drop out the subject decreased against previous year. This is a good indicator to continue applying this methodology. Also, students get higher scores than last years. These two facts are really important. We think that the mix of different active learning activities (theoretical classes, practical sessions, the use of PACS, and the collaborative work with the public presentation) improves that students are involved in their own learning process and they are more responsible on their study. For this reason, their motivation for the subject increased.

Furthermore, the new learning activities included the last academic year aroused interest for this subject. Many students of Telecommunication Engineering choose this subject and then they drop out because it is not enough related with their career. This year, we have achieved that students understand the usefulness of OOP in Telecommunication area and they are able to applied technologies connected with the concepts of this subject.

The peer review process using PACS allows to students receive feedback from other classmates immediately. They learn from the solutions of their partners. This system supports the interaction between students allowing becoming aware of their own mistakes or learning misconceptions, understanding multiple choices to solve the same problem, taking ideas to improve their own solutions or to do other similar exercises, and so on. This type of activity has allowed that students acquired deep knowledge of object oriented design. Furthermore, students put in practice the development of some personal and social skills such as critical thinking and communication abilities. Regarding the work load in accomplishing these activities, students did not spend too much time in the review process. Students are a really hard teacher with their corrections; they correct the exercises of their partners conscientiously, detecting small mistakes and explaining each error and the possible solutions.

The collaborative work performed in workgroups about a selected topic with a public oral presentation promotes the active and autonomous learning and the development of communication skills. The random selection of the person who is the responsible to present the work to their classmates guaranteed that each member of the groups worked in the collaborative work and he understood the topic selected. Students performed good and excellent presentations. They had to understand and analysis the possible uses of the topic. When students had to choose a topic of the list proposed, the most

selected topic was "Java and mobile devices" because it is the most related topic with Telecommunication Engineering.

Therefore, although the new active learning activities have a small weight in the final score of this subject, we think that these activities have contributed to motivate to the students in their own learning process. Students like new teaching methods where they are the centre of their own learning and the activities proposed are more dynamic.

Mixing different types of activities, students understand better the concepts explained during the whole course because they are working the knowledge, the comprehension and even the application level, talking in Bloom's taxonomy terms. For this reason, their acquired knowledge remains during a long time. This mix promotes the lifelong learning.

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