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# *Pilot experience applying an active learning methodology in a Software Engineering classroom*

Alicia García-Holgado, Francisco J. García-Peñalvo, María José Rodríguez-Conde
GRIAL Research Group
University of Salamanca
Salamanca, Spain
{aliciagh, fgarcia, mjrconde}@usal.es

**Abstract— Software Engineering I is a mandatory subject for undergraduate students that is taught in the second semester of the 2nd year of the Degree in Computer Sciences at the University of Salamanca (Spain). This degree exists since 1989 but it has transformed over time according to the education law changes in Spain and Europe. Software Engineering I is the first subject related to the area of software engineering that is taught in the degree. The novelty of the concepts and the need to develop abstract thinking to acquire the different competences of the subject, implies a handicap to teach the subject. The final grades obtained by the students in the subject are fairly low compared with other subjects in the degree. Moreover, the attendance to the face-to-face classes is continuously reduced throughout the semester, which affects to the continuous assessment. Some initiatives have been applied during previous school years but a global change of the subject is necessary. In order to increase the success rate of the subject and to achieve that students are involved in the learning process, authors have implemented an active learning methodology based on team working. Furthermore, two instruments have defined to measure the impact of the changes and evaluate the pilot.**

***Keywords— active learning; software engineering; team work; quantitative analysis; learning styles; project-based learning.***

## I. INTRODUCTION

The subject of Software Engineering was given at the University of Salamanca (Spain) as part of the curriculum of Diploma of Computer Sciences since 1989. Later, this degree was transformed in Technical Engineering in Computer Systems and it continuous be part both in the 1992 plan and in the 1997 plan. Finally, the degree was adapted to the European Higher Education Area (EHEA) [1-3] becoming the Degree in Computer Sciences since 2010-11 school year.

Software Engineering in the 1997 Plan was a mandatory subject of 6 credits (60 hours) that was imparted in the first semester of the third year, i.e. according to the curriculum was one of the last subjects that the students had. When the degree is adapted to the EHEA, the subject is divided in two parts, Software Engineering I in the second year and Software Engineering II in the third year.

Software Engineering I is the first subject that is taught in the area of Software Engineering of the degree, so it gives an overview of software engineering and the first activities of the software development process are addressed. The subject focuses on the early stages of the life cycle of information systems, i.e. on their definition, planning and analysis, affecting all professional profiles related to the management, consultancy and development of information systems.

Students take the course in the second semester of the second year once they have acquired programming skills. The way of approaching software development in software engineering is different from the skills acquired during the first semester; software engineering needs a higher level of abstraction. This, together the novelty of the concepts, are handicap to understand the subject.

The difficulty of addressing the subject is reflected in the attendance to the face-to-face classes and the final grades. In previous school years, the number of students who pass the subject in the first call is fairly low, around 25%, reaching 50-60% in second call. Regarding attendance to face-to-face classes, the percentage of students attending continuously is reduced throughout the semester, which influences the final grade because of 25% of the grade corresponds to continuous assessment.

Different changes in the methods used for teaching the subject has been introduced in previous years but a global change of the subject is required, maintaining the contents and competences and skills to be acquired, but modifying the methodology used.

The main goal as teachers is to increase the success rate of the subject and to achieve that students are involved in the learning process. It is important than the students acquire the instrumental and systemic competences related to the software engineering processes, as well as interpersonal skills such as collaborative work, commitment to work, etc.

With the purpose of achieving this goal, we have implemented an active learning methodology [4-7] based on team working. The present work describes the applied changes compared to previous school years and provides an analysis regarding the evolution of the learning outcomes got by the students.

The paper has been divided in four sections. Section 2 describes the methodology used to assess the experience. Section 3 presents an overview of the results. Section 4 discusses the results taking into account the final grades before implementing the active methodology. Finally, Section 5 summarizes the main conclusions of this pilot experience.

## II. METHODOLOGY

### A. Participants

The students are divided in two groups during the four years of the Degree in Computer Sciences of the University of Salamanca, Group A and Group B. The pilot experience has been carried out in the Group A, where the authors are the teachers, during the 2016-17 school year. This experimental group enrolled 72 students of which 60 are enrolled in the subject for the first time (83.33%), 4 are the second time they enroll (5.55%), 3 are the third time (4.17%), 3 are the fourth time (4.17%) and 2 are in their fifth enrollment (2.78%). Only 10 students are women (14%) and 62 students are men (86%). Most of them have 20 years old and all of them are in the age group 20 to 30.

Furthermore, the students are divided by groups of three members except in particular cases with two members. They have individual and group grades. The final grade is not only calculated with the grade getting in mid-term and final exams, all activities carry out during the semester are taken into account.

### B. Instrumentation

In order to evaluate the impact of the methodological change carried out to improve the final grades obtained by the students who study the subject of Software Engineering I in the Degree of Computer Sciences of the University of Salamanca, two data collections have been done. The aim of both data collections is to evaluate the impact achieved by implementing an active methodology in a subject that in previous school years has used a traditional methodology.

Two instruments have been developed to gather information. First instrument is formed by a set of socio-demographic questions (sex, year of birth, highest course in which student is enrolled, choice of the degree – first option, second option, etc. -, highest school level attained by his/her mother, highest school level attained by his/her father, Spanish University Entrance Exam result, other way to access to a Spanish University, average grades range in the Degree in Computer Sciences, number of enrollment in the subject, previous tertiary education or vocational education, satisfaction with the Degree) and the CEVEAPEU questionnaire (Questionnaire to Assess Learning Strategies in University Students) [8]. It is an 88 items questionnaire elaborated and validated by researchers of the University of Valencia (Spain) with the aim of providing a more complete instrument than those classically used for the evaluation of learning strategies [9-12].

Second instrument is a satisfaction questionnaire to get the students' opinion about the implemented measures. Authors have used a satisfaction questionnaire published as an annex in the doctoral dissertation "Evaluation of the impact of a teaching methodology, based on active student learning, in computing in engineering" by González Rogado [13].

In order to compare the results of both instruments, a unique identifier was included in each instrument. The student should subtract his Tax Identification Number (NIF) to the born date. For example, if the student born on 05/04/1990 and have the identity document number 12345678C, her/his unique identifier is 11803688. The teachers have access to the identification number but not to the born date, this ensure the collected data anonymity.

Both instruments have been implemented using the Google Forms tool. The Spanish version of the instruments are available in a technical report [14].

The first data collection, before the experimental intervention, was focused on detecting the learning strategies using the first instrument described above. The second data collection of the students, after the implementation of the active methodology, was focused in the students' satisfaction and students' process and learning outcomes.

As part of the second data collection, in addition to the instrument to gathering the students' satisfaction, information on students' learning outcomes has been collected. The learning outcomes are a complex variable composed of a set of both quantitative and qualitative measures of the results of different tests and activities. The qualitative measures have been analyzed through rubrics that allow producing a quantitative measure that is explained below.

Specifically, the variable to measure the learning outcomes is composed by 25 evaluation items. A Google spreadsheet have been used in order to share and manage the evaluation items between the teachers involved in the pilot. The rows of the spreadsheet are the students identified by:

- name and surname,
- identity document number,
- email address,
- number of times that he/she has enrolled in the subject
- subject modality selected (A or B),
- workgroup identify by the letter A follow by a consecutive number.

The evaluation items are divided in two groups. First, 21 evaluation items have been defined for all students. Second, a set of 4 evaluation items only for students that fail the subject at first call because they have another opportunity, a second call to improve their grades and pass the subject. Table 1 shows each item with the type of value (numeric for quantitative items and text for qualitative items), the range of values and a description.

TABLE I. EVALUATION ITEMS COLLECTED FOR EACH STUDENTS

| Evaluation item | Type | Range | Description |
|---|---|---|---|
| Absence | Numeric | 0 – 47 | Number of absence from theory and practice face-to-face classes |
| Participation | Text | - | Comments about the participation in face-to-face classes |
| Workshop 1 | Numeric | 0 – 1.25 | Grade obtained for participating or presenting his/her solution during the first workshop |
| Workshop 2 | Numeric | 0 – 1.25 | Grade obtained for participating or presenting his/her solution during the |

| | | | |
|---|---|---|---|
| | | | second workshop |
| Workshop 3 | Numeric | 0 – 1.25 | Grade obtained for participating or presenting his/her solution during the third workshop |
| Workshop report | Numeric | 0 – 1 | Grade for delivering the report of the workshop previously presented in classroom |
| Exercise 1 | Numeric | 0 – 10 | Grade obtained in the first UML exercise (a class diagram) collected as part of the continuous assessment |
| Exercise 2 | Numeric | 0 – 10 | Grade obtained in the second UML exercise (a class diagram) collected as part of the continuous assessment |
| Continuous assessment | Numeric | 0 – 10 | The sum of: average of exercise 1 and exercise 2; workshop 1, workshop 2 and workshop 3 with a maximum of 1.25 points; workshop report; and presentation |
| Milestone 1 | Numeric | 0 – 10 | Result of the rubric to evaluate the milestone 1 of the final project |
| Milestone 2 | Numeric | 0 – 10 | Result of the rubric to evaluate the milestone 2 of the final project |
| Milestone 3 | Numeric | 0 – 10 | Result of the rubric to evaluate the milestone 3 of the final project |
| Final project | Numeric | 0 – 10 | Average of the grades getting in the three milestones (milestone 1, milestone 2, milstone 3) |
| Presentation | Numeric | 0 – 1 | Evaluation of the presentation in classroom of the final project |
| Test 1 | Numeric | 0 – 10 | Grade of the first mid-term exam abouth theory concepts |
| Test 2 | Numeric | 0 – 10 | Grade of the second mid-term exam about theory concepts |
| Total mid-term tests | Numeric | 0 – 10 | Average of mid-term exams (test 1 and test 2) |
| Theory final exam C1 | Numeric | 0 – 10 | Grade of the theory concepts part of the final exam (first call) |
| Practice final exam C1 | Numeric | 0 – 10 | Grade of the practice part of the final exam (first call) |
| Total final exam C1 | Numeric | 0 – 10 | Average of final exam parts in the first call (theory final exam and practice final exam) |
| Final grade C1 | Numeric | 0 – 10 | Sum of 25% of continuous assessment, 30% of final project and 40% of the total final exam and a subjective part related to class participation, interest, etc. (first call) |
| Theory final exam C2 | Numeric | 0 – 10 | Grade of the theory concepts part of the final exam (second call) |
| Practice final exam C2 | Numeric | 0 – 10 | Grade of the practice part of the final exam (second call) |
| Total final exam C2 | Numeric | 0 – 10 | Average of final exam parts in the second call (theory final exam and practice final exam) |
| Final grade C2 | Numeric | 0 – 10 | Sum of 25% of continuous assessment, 30% of final project and 40% of the total final exam and a subjective part related to class participation, interest, etc. (second call) |

There are some qualitative items that appears as quantitative in the Table 1 because they have been analyzed using rubrics that transform qualitative measures in quantitative.

In particular, three rubrics has been defined for evaluating the quality of the final project for each group of students, one per each milestone of the final project. First rubric, for the evaluation of milestone 1, has four levels of performance: not passing, equivalent to 0 points over 10; fair, equivalent to 4; good, equivalent to 7; and excellent, equivalent to 10 over 10. The rubric assesses eleven criteria. Each criterion has a weight in the final grade.

Second and third rubrics, for the evaluation of milestone 2 and 3 respectively, has five levels of performance because there were criteria that required to define a level between not passing and fair, the barely pass level is equivalent to 2 points over 10. Both have four criteria.

### *C. Study design*

Two course modalities were defined in order to provide an alternative to students enrolled in the subject for second time or more. On the one hand, the modality A with a more traditional approach towards a final evaluation designed for those students who have previously attended the subject or who cannot attend the face-to-face classes for work reasons or overlapping with other subjects. This modality does not include continuous assessment but they can attend to the face-to-face classes and do the mid-term exams. Moreover, they must deliver the final project and defend it in group. In addition, students of previous years may keep the grade received in the final project and the grade received in the continuous assessment.

On the other hand, the modality B (active learning) is focused on a continuous assessment approach based on active learning through project-based learning [15-17]. The unifying thread is the development of the final project together with the theoretical and practical contents that are needed to carry it out. The face-to-face classes are structured following the milestones of the software engineering process (Fig. 1), not the contents of the subject. They are structured based on an active approach guided by the milestones of the software process. The final project consists in the development of an analysis model in software engineering on a specific topic; the groups should provide their own technological solution. The materials are available on the virtual campus provided by the University of Salamanca (Spain), based on Moodle. During face-to-face classes emphasis is placed on relevant knowledge for developing the final project and besides most of the time is dedicated to work in groups with teachers support to solve questions or to guide about the software engineering process. The modality B is a kind of flipped classroom [18, 19]; face-to-face classes are prepared outside the classroom and there is a more active attitude in the classroom. It involves attending and participating in theory and practice classes and performing exercises, workshops, oral presentations, partial deliveries of the final project, etc.

Fig. 1 shows the Gantt chart provided to the students in order to inform them about the planning of the subject

throughout the semester. In particular, the final project is divided in two phases of the software development process. Initial phase is focused on the elicitation of the requirements; they should prepare a document with the requirements defined by themselves and a use case diagram to model it. At the end of this phase the first milestone is programmed. Regarding the second phase, it is focused in the requirements analysis. It is divided in two milestones, one for defining the domain model with a class diagram and one for the realization of the use cases using UML interaction diagrams, such as sequence diagrams.

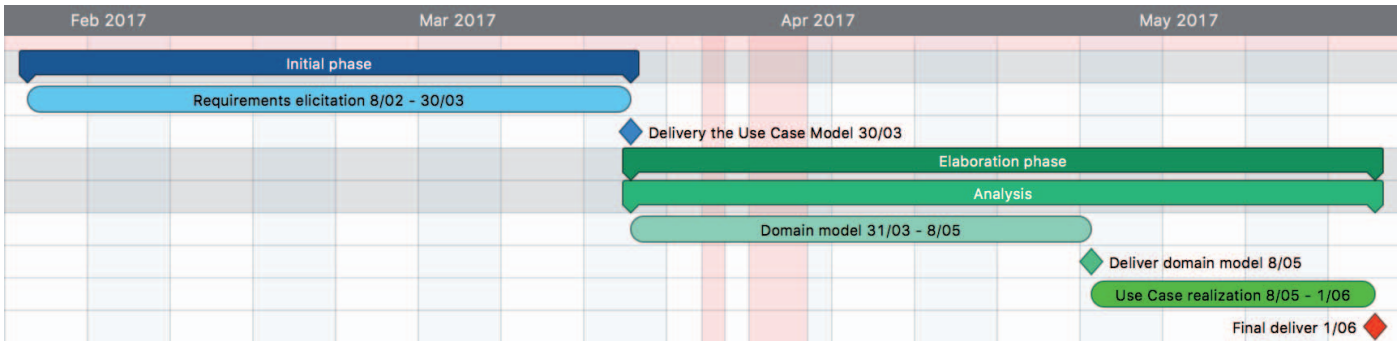


Fig. 1. Gantt chart with the subject planning

*D. Data collection and analysis*

First, each student has selected the course modality through a survey in the Virtual Campus. 63 students (87.5%) have selected and completed the continuous assessment modality (B) and 9 students has selected the modality A. All students that select the modality A are students enrolled in the course for second or more times.

The evaluation items have collected in real time per each student. Teachers filled the spreadsheet with the different values when some of the activities or tasks were done by the students. The absence has been collected every day using an attendance list with full name and signature. The evaluation of the milestones, as one of the most important parts of the course, have been done using the rubrics during the week after the delivery of the documents associated to the milestone.

The students of the subject voluntarily participated in this study and decided whether to complete the questionnaires. Anonymity of personal information was guaranteed.

The first data collection was carried out during the first week of the semester, at the beginning of the subject, and the second data collection has been done once face-to-face classes finished and final project have been completed, coinciding with the week before the final exam.

To analyze the data, a first database in a Excel file was obtained from the automatic entry of results of the instrument applied in Google Form. The data collected during the application of the second instrument has been added to the database, always taking into account the student's unique identifier. The database in Excel has been imported into the SPSS Statistics 23 (License of the University of Salamanca Campus).

To achieve the main goal of this work, demonstrate that the final grades of the students have improved due to the methodological changes, the analysis has been focused on the learning outcomes. First, a basic descriptive analysis of items that compose the complex variable of learning outcomes has been done (mean, standard deviation and distribution of the variables). Once the parametric characteristics of the simple variables (items) have been determined, a multiple regression analysis is carried out step by step on the criterion variable (final grade C1) in order to determine the items that contribute most to explain the variability of this variable.

Then, the results of the pilot has been compared with the results obtained in previous school years in which the same teachers applied a traditional methodology, but using the same evaluation items. A non-parametric contrast based on Chi-square test has been made to determine the equality or not in percentages of grades (significance level of 0.05).

## III. RESULTS

First, a global view of the socio-demographic results obtained during the first data collection. The first questionnaire was answered online by 55 students but 4 answered has been discarded because of three are repeated answers and one has invalid data. 41 answers are from men (80.39%) and 10 from women (19.61%). Only 5 of the students (9.8%) selected the career in second place, everyone else selected in first place (90.2%). Regarding the parents' level of education, highlight all of them have at less primary education and around 40% have tertiary studies (see Fig. 2 for more detail). According to the grades accumulated during the degree, 33 students have an average grade between 5 to 6 (64.7%), 10 are between 7 to 8 (19.6%) and 3 are between 9-10 (5.9%), only 5 students say that have an average grade under 5 (9.8%) (see Fig. 3).

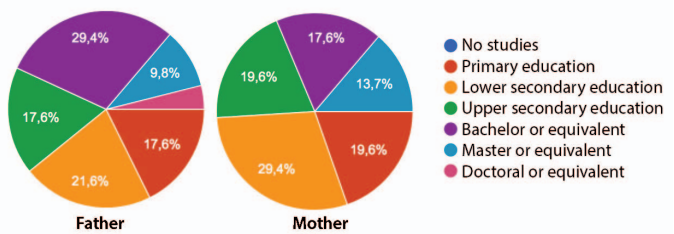


Fig. 2. Highest school level attained by their parents.

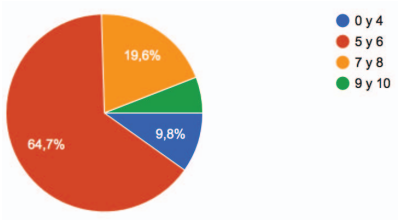


Fig. 3. Average grades range in the Degree in Computer Sciences.

Regarding the satisfaction about the methodological change, the second instrument was answered by 44 students, although 15 of them do not answer the first data collection. This figure is possible because of there are 72 students and 21 do not answer the first instrument. Most of the answers show a high satisfaction degree. 72.72% of the students (34 of 44) think that have learned more with this methodology than if they had studied by themselves and it has allowed to achieve the learning objectives. 63.64% recommend apply this methodology in other subjects. 61.36% of answers say that the new methodology helps to learn and 72.73% think that the teacher has helped to understand the contents.

In this work, the analysis is focused on the evaluation items that provide the learning outcomes of each student of the modality B along the semester (see Table 1).

Table 2 presents the basic descriptive statistics for each of the evaluation items collected about the students of modality B. The variables analyzed are within a range of 0-10 points, as is usual in the student assessment system in Spain. The score equal to or greater than 5.00 is considered. This is the cut-off grade to pass the evaluation items analyzed. The lowest score has been obtained in the evaluation item "Exercise 2" because during this exercise the students were not focused on class diagrams, they were working on the first milestone related to use cases to describe software requirements. The highest is the "Final project", because it is the main work during the semester, all the activities, contents and the planning of the subject have been focused on this item. At the same time, the greater variability has also been found in the "Exercise 2" (Standard Deviation 2.292). The reason for this dispersion may be due to some students studied the previous contents related to class diagrams although they were working in other part of the planning. The most homogeneous evaluation item has been the "Final project" (Standard Deviation 1.002) because this evaluation item reflects the final results, not the process to get it. The evaluation of each milestone is not a final grade, it is a grade that change over time to take into account the improvements done by the students in order to simulate a real software development process. This variability difference is also observed through the scores of quartiles 1, 2 and 3.

As the Table of Normality shows (Table 3), all the distributions corresponding to the scores in evaluation items, with the exception of "Final project" ($p < .01$), follow a normal distribution (ns .05), which allows us to apply parametric treatment in the following multivariate statistical analysis.



TABLE II. DESCRIPTIVE RESULTS FOR STUDENTS WITH MODALITY B (N = 63)

| Variables | N | Min | Max | Mean | Stdev | Sk | Rku | Q1 | Q2 | Q3 |
|---|---|---|---|---|---|---|---|---|---|---|
| Exercise 1 | 55 | 2.0 | 8.5 | 5.145 | 1.474 | .109 | .634 | 4.00 | 5.00 | 6.50 |
| Exercise 2 | 62 | .00 | 10.00 | 2.976 | 2.292 | .937 | .599 | 1.44 | 2.75 | 4.00 |
| Test 1 | 63 | .53 | 10.00 | 4.702 | 1.964 | .112 | .595 | 3.00 | 4.56 | 6.32 |
| Test 2 | 50 | 1.17 | 9.33 | 4.330 | 1.692 | .374 | .662 | 3.17 | 4.33 | 5.21 |
| Total mid-term tests | 63 | .26 | 9.66 | 4.069 | 1.976 | .012 | .595 | 2.86 | 4.30 | 5.47 |
| Continuous assessment | 63 | .25 | 10.50 | 4.682 | 2.185 | .516 | .595 | 3.12 | 4.37 | 6.00 |
| Final project | 63 | 6.35 | 10.00 | 8.413 | 1.002 | -.570 | .595 | 7.50 | 8.70 | 9.20 |
| Theory final exam C1 | 61 | 2.27 | 9.66 | 4.937 | 1.369 | .451 | .604 | 4.05 | 4.91 | 5.78 |
| Practice final exam C1 | 61 | .50 | 8.75 | 4.746 | 2.152 | -.219 | .604 | 3.08 | 4.85 | 6.40 |
| Final grade (C1&C2) | 63 | .00 | 10.00 | 5.747 | 1.957 | -.713 | .595 | 5.00 | 6.14 | 7.00 |

TABLE III. RESULTS OF THE NORMALITY TEST FOR THE DISTRIBUTION OF THE STUDY VARIABLES

| | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | *Statistical* | *df* | *Sig.* | *Statistical* | *df* | *Sig.* |
| Exercise 1 | .119 | 44 | .134 | .975 | 44 | .432 |
| Exercise 2 | .121 | 44 | .113 | .949 | 44 | .051 |
| Test 1 | .077 | 44 | .200* | .971 | 44 | .332 |
| Test 2 | .103 | 44 | .200* | .975 | 44 | .460 |
| Total mid-term tests | .073 | 44 | .200* | .958 | 44 | .111 |
| Continuous assessment | .110 | 44 | .200* | .963 | 44 | .163 |
| Final project | .186 | 44 | .001 | .931 | 44 | .011 |
| Theory final exam C1 | .060 | 44 | .200* | .971 | 44 | .321 |
| Practice final exam C1 | .099 | 44 | .200* | .958 | 44 | .110 |
| Final grade (C1&C2) | .135 | 44 | .042 | .950 | 44 | .055 |

*. This is a lower limit of the statistical significance

a. Correction of the Lilliefors' significance

TABLE IV. CORRELATIONS BETWEEN THE GRADES OF THE DIFFERENT TESTS

| | | Exercise 1 | Exercise 2 | Continuous assessment | Test 1 | Test 2 | Total mid-term tests | Theory final exam | Practice final exam |
|---|---|---|---|---|---|---|---|---|---|
| Exercise 1 | Pearson's Corr. | 1 | | | | | | | |
| | N | 55 | | | | | | | |
| Exercise 2 | Pearson's Corr. | .400** | 1 | | | | | | |
| | N | 54 | 62 | | | | | | |
| Continuous assessment | Pearson's Corr. | .626** | .778** | 1 | | | | | |
| | N | 55 | 62 | 72 | | | | | |
| Test 1 | Pearson's Corr. | .443** | .404** | .454** | 1 | | | | |
| | N | 55 | 62 | 67 | 67 | | | | |
| Test 2 | Pearson's Corr. | .270 | .370** | .419** | .476** | 1 | | | |
| | N | 45 | 49 | 52 | 52 | 52 | | | |
| Total mid-term tests | Pearson's Corr. | .462** | .452** | .519** | .907** | .876** | 1 | | |
| | N | 55 | 62 | 72 | 67 | 52 | 72 | | |
| Theory final exam C1 | Pearson's Corr. | .463** | .405** | .395** | .740** | .709** | .812** | 1 | |
| | N | 55 | 60 | 68 | 65 | 52 | 68 | 68 | |
| Practice final exam C1 | Pearson's Corr. | .432** | .430** | .508** | .580** | .468** | .603** | .621** | 1 |
| | N | 55 | 60 | 68 | 65 | 52 | 68 | 68 | 68 |

** The correlation is significant at the 0.01 level (bilateral)

TABLE V. SUMMARY OF THE MODEL FOR THE CRITERION VARIABLE: FINAL GRADE C1

| Model | R | $R^2$ | Adjusted $R^2$ | Standard error | Change statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *$R^2$ change* | *F change* | *df1* | *df2* | *Sig. F Change* |
| 1 | .765[a] | **.585** | .574 | .95928 | .585 | 50.805 | 1 | 36 | .000 |
| 2 | .869[b] | **.755** | .741 | .74807 | .170 | 24.199 | 1 | 35 | .000 |
| 3 | .920[c] | **.847** | .834 | .59931 | .092 | 20.531 | 1 | 34 | .000 |
| 4 | .939[d] | **.882** | .868 | .53388 | .035 | 9.845 | 1 | 33 | .004 |
| 5 | .947[e] | **.897** | .880 | .50801 | .014 | 4.447 | 1 | 32 | .043 |

[a] Predictor variables: (Constant), Practice final exam C1

[b] Predictor variables: (Constant), Practice final exam C1, Final project

[c] Predictor variables: (Constant), Practice final exam C1, Final project, Exercise 2

[d] Predictor variables: (Constants), Practice final exam C1, Final project, Exercise 2, Theory final exam C1

[e] Predictor variables: (Constants), Practice final exam C1, Final project, Exercise 2, Theory final exam C1, Exercise 1



TABLE VI. COEFFICIENTS FOR THE FINAL MODEL ON THE CRITERION VARIABLE: FINAL GRADE C1

| Model | Unstandardized coefficients | | Standardized coefficients | t | Sig. |
|---|---|---|---|---|---|
| | *B* | *Standard error* | *Beta* | | |
| (Constant) | -1.249 | .692 | | -1.805 | .081 |
| Practice final exam C1 | .236 | .058 | .330 | 4.059 | .000 |
| Final project | .430 | .083 | .321 | 5.153 | .000 |
| Exercise 2 | .176 | .039 | .300 | 4.559 | .000 |
| Theory final exam C1 | .271 | .088 | .246 | 3.075 | .004 |
| Exercise 1 | .136 | .065 | .130 | 2.109 | .043 |

[a] Dependent variable: Final grade C1

Then, in Table 4, the correlation between the scores of the different evaluation items is checked (taking into account that the autocorrelation is not consider, i.e., the "Continuous assessment" variable is the indirect result of other two variables "Exercise 1" and "Exercise 2" because it is derived from them). Analyzing the table of bivariate correlations, we observe that the correlations are significant (ns .05) among all the variables (different to 0) and range between .03 and 0.5 among the non auto-correlated variables. This gives an idea of the relationship between the production of students. That is to say, a certain consistency in the results is observed, who is evaluated with high grades in the tests, also he/she is evaluated with high grades in the rest of the evaluation items and vice versa.

Finally, the variability of the total score in "Final grade C1" (criterion variable) is analyzed from the grades in the previous evaluation items (predictor variables): Exercise 1, Exercise 2, Continuous assessment, Final project, Test 1, Test 2, Total mid-term tests, Theory final exam C1 and Practice final exam

C1. The objective is to know which of all the evaluation items explains the highest percentage of the variability of the final grade in the first call. That is to say, what is the evaluation item that most discriminate among the students who have pass through the modality B (active learning) and contributes more to the final grade.

As Table 5 shows about the criterion variable "Final grade C1", after performing a stepwise regression analysis, 89.7% is the percentage of variance of the criterion explained by the predictors in the more exhaustive model, and the variable that explains better is the first introduced, "Practice final exam C1".

Regarding the regression model (Table 6) we take into account that the range of scores is the same for all the variables. This allows to define the regression equation in direct scores:

$$\hat{y} = -1{,}249 + 0{,}236\ Practice\ final\ exam\ C1 + 0{,}43\ Final\ assignment + 0{,}176\ Exercise\ 2 + 0{,}271\ Theory\ final\ exam\ C1 + 0{,}136\ Exercise\ 1$$

## IV. DISCUSSION

The same teachers taught together the Software Engineering I in the 2013-14 school year. They applied a traditional methodology. The evaluation items using this methodology were almost the same items evaluated during the pilot experience with the active methodology in 2016-17 school year (Workshop 1, Workshop 2, Workshop 3, Workshop report, Exercise 1, Exercise 2, Continuous assessment, Final project, Test 1, Test 2, Total mid-term tests, Theory final exam C1, Practice final exam C1, Total final exam C1, Final grade C1, Theory final exam C2, Practice final exam C2, Total final exam C2, Final grade C2).

In particular, the comparison has been done between the results received by the Group A during the 2013-14 school year and the results received by the students with modality B during the pilot experience in 2016-17. In 2013-14 the Group A enrolled 79 students of which 50 were enrolled in the subject for first time (63.29%), 22 were the second time they enrolled (27.85%) and 7 were the third time (8.86%). Only 17 students were women (21.52%) and 62 men (78.48%).

One of the main differences between both experiences are the scores got in the "Final project". Both school years the students were divided by groups of three members, except in particular cases with two members, in order to work in the final project. Although in 2013-14 there were more students, some of them were enrolled for second or more times and decided to keep their grades related to the final project. Finally, 23 groups in 2013-14 and 22 groups in 2016-17 had to deliver the final project. In 2013-14, 8 of the 23 projects received a grade of fail or not present (34,78%); on the contrary in 2016-17 no project received a grade of fail or not present, 22 of the 22 projects pass with grade of C or more. Furthermore, in 2013-14 not all projects were delivered in first call and only 10 projects pass, however, in the first call of 2016-17 all projects were delivered and 20 projects pass.

The average of final projects that pass in 2013-14 was 6.4 over 10 and in 2016-17 was 8.37 over 10 (1.97 difference points). A comparison of the grades in both school years is shown in Table 7.

TABLE VII. COMPARISON OF THE GRADES RECEIVED IN THE FINAL PROJECT

| Grade | 2013-14 | 2016-17 |
|---|---|---|
| A (Excellent) | 1 | 6 |
| B (Remarkable) | 6 | 14 |
| C (Pass) | 8 | 2 |
| Fail | 5 | 0 |
| Not present | 3 | 0 |
| **Total** | 23 | 22 |

Regarding the final exam in 2016-17, 61 of the 63 students in modality B did the final exam in first call and 35 pass it (57.38%). However, 7 of the 9 students in the modality A (traditional methodology) did the exam and only one pass it (14.29%). This supposes a 50% of students who pass the subject in first call. During the 2013-14 school year, 65 of 79 students did the final exam in first call but only 10 pass it (15.38% of students who did the final exam and 12.86% of total number of enrolled students); similar percentage than students in the modality A in 2016-17.

TABLE VIII. COMPARISON OF THE FINAL GRADES

| Grade | 2013-14 | 2016-17 |
|---|---|---|
| Outstanding | 0 | 1 |
| A (Excellent) | 1 | 2 |
| B (Remarkable) | 3 | 20 |
| C (Pass) | 29 | 27 |
| Fail | 34 | 12 |
| Not present | 12 | 1 |
| **Total** | 79 | 63 |

Finally, in 2016-17 school year, 69.44% (50 of 72) of the total number of students enrolled in the subject have pass, where 63.89% were students that selected the modality B (46 of 72) and 5.56% were students that selected the modality A (4 of 72). On the other hand, in 2013-14, only 41.71% (33 of 79) of the total number of students pass the subject. Table 8 shows a comparison between the final grades in both experiences, traditional methodology in 2013-14 and active learning in 2016-17.

To determine the equality or not in percentages of grades a non-parametric contrast based on Chi-square test has been made (significance level of 0.05). The contrast of the hypothesis offers a Chi-square of 174.84, with 5 degrees of freedom, with an associated value of acceptance probability of the equality hypothesis less than .001. Therefore, there is a clearly difference between the academic results of the two school years, in favor of the experience carry out in 2016-17, in which an active learning methodology has been applied. More specifically, the difference occurs in the decrease of the fail and

not present percentage and the percentage of B (Remarkable), as shown in the Fig. 4.

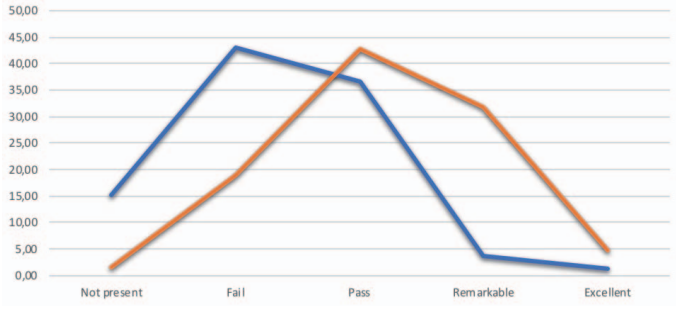


Fig. 4. Comparison of percentage distribution in academic performance levels, between 2013-14 and 2016-17.

## V. Conclusions

In this paper, the aim was to analyze the evolution of the learning outcomes got by the students in the subject of Software Engineering I in the Degree of Computer Sciences of the University of Salamanca during the 2016-17 school year after applying active learning through project-based learning.

The methodological change has allowed increasing the number of students that pass the subject at first call. In particular, the percentage has increased around 20%, from 41.71% to 63.89%, with a high success rate in students that selected the modality with an active learning approach; and the average of final grades has increasing in 1.49 over 10.

Regarding the final project developed in groups, the active learning through project-based learning has allowed to reach a success rate of 100% in the modality B with an average of 8.37 over 10 points. The percentage has increased around 35% between the 2013-14 school year and the pilot experience.

Moreover, the grades received in the final exam at first call has increased around 35% too, from 12.86% to 50%. Besides, the percentage of pass students in 2013-14 is similar to the percentage of pass students in the modality A in 2016-17, both with a traditional methodology.

The high success rate in the learning outcomes allows to state that the students acquire the instrumental and systemic competences related to the software engineering processes, as well as interpersonal skills such as collaborative work.

The analysis results have shown that the applied methodology is a good solution to increase the success rate in the subject of Software Engineering. Although the pilot experience has been applied only in a specific context, the experience can be adapted to similar subjects in other degrees and universities.

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