Using peer-assessed returnables in multiple stages to improve learning in computer organization courses

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***Abstract*—In this work a teaching tool called *returnable* is described. A returnable is a set of exercises whose value comes from the way they are used. The returnable can became a motivating tool, useful to encourage student's work in the early stages of the course and to help the teacher with the continuous assessment of students.**

Keywords—Continuous evaluation; peer assessment; computer organization.

I. INTRODUCTION

The adaptation of university studies in Spain to the new Bologna model has brought not only a reorganization of the materials, subjects and courses, but also changes in how students should be assessed. These changes are especially relevant, since they affect which learning aspects should be evaluated. Instead of organizing the evaluation exclusively around the contents of a course or subject, the new assessment also deals with the skills and behaviors that students should achieve. In order to assess these competencies, the student must be instructed during his or her learning process. That is, a student that has not been taught cannot be properly assessed. At least, the student requires sufficient tools to enable self-directed learning.

In this context, a new challenge arises: to integrate learning and evaluation of contents, skills, as well as behaviors, which can be specific to the subject or more general (i.e., related to the whole grade) along the course schedule making use of the same resources (or even less) than in the previous curriculum. For example, classroom teaching and tutoring hours have become scarcer, since the introduction of the new degrees has involved, in many cases, a significant reduction in the number of hours assigned to these activities.

To reach this goal there is not a single answer. The problem must been tackled using multiple tools and strategies that, wisely combined, will provide the targeted learning outcomes. In this paper, we present a simple yet effective tool, named *returnable*, devoted to teaching and learning specific topics of computer organization courses as well as other general competences in computer engineering and computer science degrees. This tool has been used in the subject *Computer Fundamentals* [1], which is included in the curricula of the *Bachelor's Degree on Computer Engineering* and the *Bachelor's Degree on Telecommunications Engineering,* which are given at Universitat Politècnica de València.

A returnable consists of a set of exercises organized in topics. Despite its simplicity, the main value of the tool comes from its usage, which is organized around peer assessment. There is a lot of previous work related to peer assessment approaches. An important part of these studies focuses on the benefits of peer review in class. Several authors [2,3] claim that because evaluation and criticism are high-level skills in the Bloom's Taxonomy, students participating in peer-review processes do not only enhance their learning of the basics of the subject, but also achieve higher-level learning outcomes. Hamer [4] and Wolfe [5] emphasize the increasing amount of feedback opportunities for learning while Davies and Barrow [6] detect that by evaluating the work of their peers, students increase their self-assessment abilities.

Because of these benefits, peer review schemes have been proposed in the literature for more than 30 years [7]. These schemes have been applied to several disciplines, including Industrial Engineering [8,9], Mathematics [10], Education [11] and Accounting [12]. More recently, there has been research work regarding Computer Architecture [13] and Operating Systems [14].

The remainder of this paper is organized as follows. Section 2 describes the returnable tool, its usage, as well as its main features. Section 3 presents an experience with the tool and discusses the results of a survey for the students that were involved. Finally, conclusions are presented in Section 4.

II. DESCRIPTION, USAGE, AND PROPERTIES OF A RETURNABLE

The main objectives that the returnable pursues are three: first, to motivate students to work with the entire course contents, both theory and practice, from the beginning of the course; second, to assist the teacher to assess students work in

Fig 1. Workflow of a returnable.

a continuous way; third, to help the students to develop cross-curricular and high-level competencies. Achieving these three objectives must be done without overloading the students and the teacher.

A returnable cannot be defined as just a set of handouts with exercises, since its main value comes from the way it is used, which yields a set of features that are helpful to reach the aforementioned objectives. Next sections describe the returnable components, its usage, and the features that it offers

A. Components of a returnable

To enable continuous assessment, there is a returnable for each topic of the course. A returnable is composed of:

- A pair of handouts with exercises. Each handout includes a different exercise that works with a part of the contents and skills regarding the corresponding topic. Together, both exercises deal with the whole topic objectives. In addition, the exercises are presented similarly to how they will be proposed in other future evaluation tests.
- Evaluation criteria. The handouts include information to assist peer assessment. Of course, the main objective of this information is to help students to perform peer assessment. However, it also achieves two additional goals. On the one hand, it promotes consistent marks, since all the peers use the same criteria. On the other hand, it provides knowledge about the importance of the different parts and aspects of the exercises, which can be of use in the study to perform future evaluation tests.

B. Usage of a returnable

The usage of a returnable transforms the described simple set of handouts into a powerful tool, which aids both students and teachers during the learning process. Fig. 1 presents the usage of a returnable as a workflow composed of several stages. The work in stages highlighted in green is done by the teacher while the work of the stages highlighted in orange is performed by the students. The last stage is assigned to the teacher, but it is also the first step in the study for future evaluation tests, so it is highlighted in both colors. The different stages are described below.

Preparation. Once a given topic of the course has been covered during class time, the teacher prepares the documentation described in Section 2.A.

Distribution. Each student gets one of the handout models included in the pair. However, it is important to perform a nearly even distribution, since it is critical for the proper application of the returnable. An easy way to accomplish this is relying on the teacher to manually distribute the two models. However, this method does not help to motivate the student. Alternatively, there are several simple ways to catch students' attention while avoiding very unequal distributions. For example, the teacher can ask the students to toss a coin and get the handout depending on the result, or query about information derived of personal data (e.g., number of letters in the student's name, month of birth, preferred colour among two options, etc.) and use this information to assign the model.

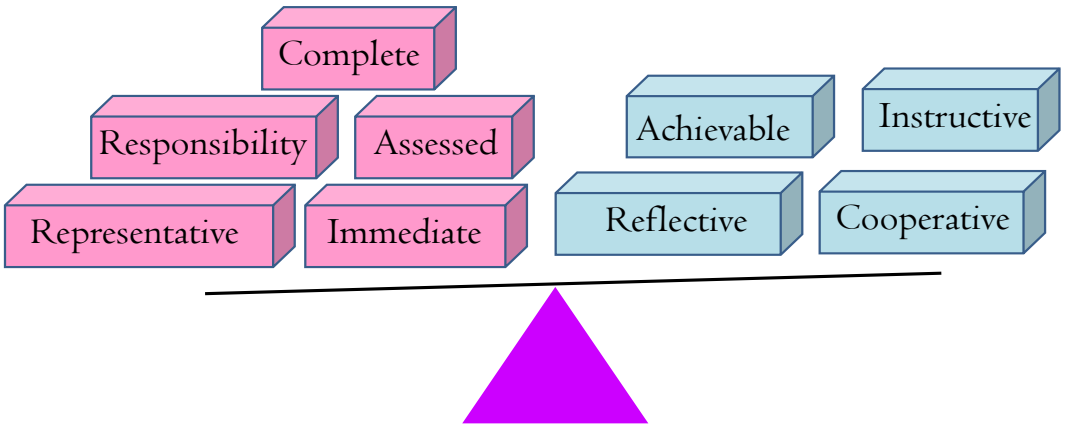

Fig 2. Features of a returnable.

In this way, the student feels that he/she has some freedom to choose his/her assigned homework, which is motivational.

Resolution. Each student must solve his/her copy of the exercises as homework. There is no restriction about how to perform this task, that is, a given student can do this alone or with the aid and collaboration of other classmates. The deadline to return the solved exercises is about one week. This relatively short deadline prevents students from delaying their work and the associated learning activities. However, it is advisable to query the students about their agenda regarding other academic subjects. Again, this makes students feel they are taking part in their own learning process. In contrast, an imposed deadline may lead the students to cheat and get the answer to the exercises without actually work on them.

Exchange. Once the mentioned deadline has passed and students have returned their exercises to the teacher, the teacher redistributes again the returned handouts as soon as possible, taking care that every student gets a handout model different from the model he/she solved previously. This step is also critical, because both models work on complementary parts of the corresponding topic. Thus, it is advisable that all the students get access to both models to get a more comprehensive learning.

Assessment. In this stage, the evaluation criteria commented in Section 2.A is used to help students to evaluate the work performed by their classmates in the redistributed handouts. A key aspect to consider is that the teacher does not provide solutions, so evaluators have to solve the exercises by themselves. To do that, an evaluator can develop a complete solution or base it on the work of another classmate. Different solutions can also be compared and analyzed. Note that, according to Bloom's Taxonomy, analysing and assessing other's solutions is a higher level task than simply solving the exercise [2,3]. Finally, the period to perform the evaluation is similar to the period given to solve the exercise.

Review. Students deliver, again, the evaluated handouts to the teacher, who may review a subset of them. The review has multiple goals: i) to reduce the stress that some peers suffer when evaluating other classmates, ii) to detect important errors when applying the evaluation criteria, and iii) to find common errors incurred by most students, hinting the teacher about the weakest spots that must be reinforced in the learning process. Different strategies can be used to choose which evaluations should be reviewed (e.g., a complete review of all the evaluations, a random review, focusing on extreme marks, based on previous marks, etc.). The discussion about the benefits and drawbacks of different strategies is out of the scope of this work.

Return. Finally, the returnable comes back to the author that solved it in the resolution stage. It returns with the marks and relevant comments produced in the assessment and review stages. Therefore, an initially simple set of exercises becomes a powerful learning and study tool through the multiple stages of its usage.

C. Features of a returnable.

Fig. 2 represents the main features a returnable offers. A subset of these features (highlighted in red) is partially opposed to the other subset (highlighted in blue). However, the design and usage of the returnable properly balance both subsets. A detailed description of these features is given below focusing on the opposing characteristics to be considered.

Complete and representative vs. achievable. The tool helps the student to learn all the course contents, since it involves both theory (e.g., main ideas and concepts) and practice (e.g., methods, procedures, and skills) aspects of every topic in the course. In addition, a returnable is *representative* of how students will be assessed in future main evaluation tests of the course.

On the other hand, the returnable is *achievable*. The effort and the time required to solve a returnable is bounded. The design of a returnable takes into account that students are attending others courses, in order to prevent students from becoming burned up by too much homework.

Assessed vs. instructive. The tool *evaluates* the progress of the students to help the teacher verify that the learning process is progressing successfully. But, at the same time the returnable is *instructive*, that is, students learn while doing the returnable's work. The aim is to show students if they are in the path to reach the learning objectives.

Immediate vs. reflective. One of the main reasons why the tool is instructive is because it is *immediate*. Students begin working with the returnable as soon as they are taught enough to use the tool. This promotes early study and allows students to apply assessment results to improve their learning process.

TABLE 1. GLOBAL RETURNABLE EXPERIENCE DATA PER ACADEMIC YEAR.

Computer Fundamentals	Academic Year	2010/2011	2011/2012	2012/2013
Bachelor's Degree on Computers Eng	Groups	1	3	3
	Students	40	110	110
	Teachers	1	3	3
Bachelor's Degree on Telecommunications Eng.	Groups	-	-	3
	Students	-	-	120
	Teachers	-	-	3
Total	Groups	1	3	6
	Students	40	110	230
	Teachers	1	3	4

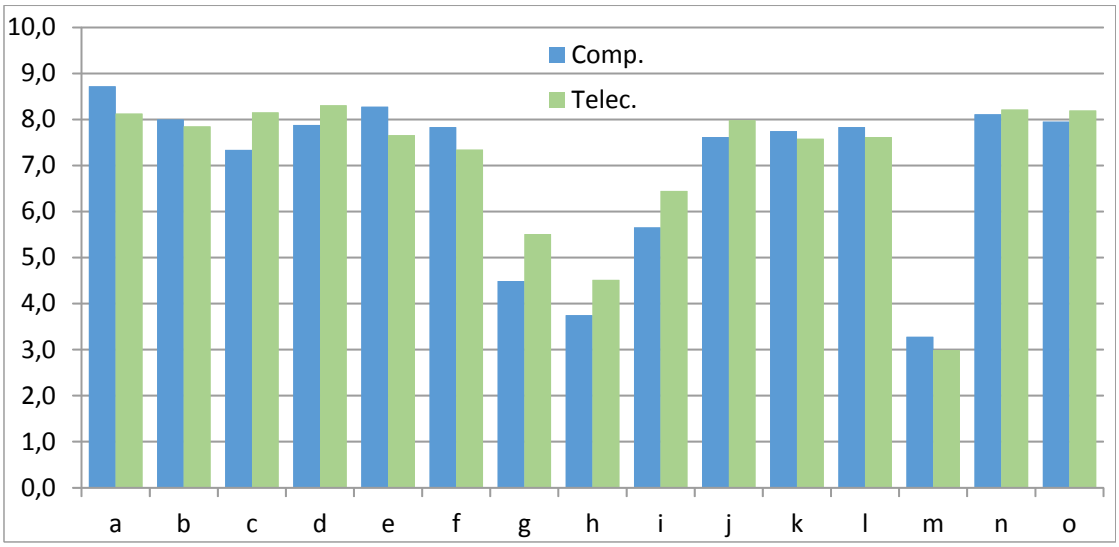

Fig. 3. Survey numerical results per question for the Degree on Computers Engineering and Degree on Telecommunications Engineering.

Nevertheless, it is important that students are reflective about their work. Since this task requires time, the teacher and his/her students must reach an agreement about the time needed to work with the returnable and choose appropriate deadlines**.**

Cooperative vs. individual responsibility. Finally, this tool encourages two attitudes: cooperation and responsibility. Cooperation is a powerful skill, since when a classmate helps other one to solve an exercise, both improve their own expertise. However, before resorting to external aid, a student must be responsible of his/her own learning by seriously trying to solve the homework.

III. Experiences and Results

Returnables were used during the academic year 2010 for the first time, in a single group of the Computer Fundamentals subject belonging to the Bachelor's Degree on Computer Engineering offered by the *Escuela Técnica Superior de Informática* at Universitat Politècnica de València. The experience was repeated the subsequent year, this time with the participation of three teachers and three groups of the same subject. Both teachers and students agreed on their satisfaction using this tool.

In the academic year 2012 the use of returnables was maintained in the aforementioned three groups of Computer Fundamentals and has been exported to a subject with the same name but belonging to the Bachelor's Degree on Telecommunications Engineering offered by the Escuela Técnica Superior de Ingenieros de Telecomunicación. Three new student groups and a teacher have joined the experience this year. Table I shows the global data for the different academic years. In current academic year 2013, returnables are being used by new five teachers and in new two courses of Bachelor's Degree on Telecommunications Engineering. This work presents results and conclusions of the last three years. Authors want to wait until the end of the year to present new results and conclusions, especially from the new two courses.

Both subjects are developed during the autumn semester. Once the subjects finished the students were asked to fill a short survey with 15 questions and a free comment space regarding different aspects of the returnables experience. Total number of students that answered it was 46 from Degree on Computers and 65 from Degree on Telecommunications.

Following is a description of the questions used in the survey and the discussion of the results obtained. For each question the student can select one among five answers: Totally disagree; Disagree; Neutral; Agree; Totally agree. The values assigned to each answer are 0, 2.5, 5, 7.5, and 10, respectively.

Question list:

About solving the returnable:

a) The allowed time has been adequate.
b) The required effort has been adequate.
c) The questions of the returnable included everything asked in the exam.
d) The questions of the returnable helped me to prepare the exam.

About peer-assessment procedure:

e) The allowed time has been adequate.
f) The required effort has been adequate.
g) The required effort has been greater than the effort required for the resolution of my own returnable.

h) I would have preferred the questions of my classmate were the same than those appearing in my own returnable.

i) Assessment criteria are clear enough.

j) Taking into account my limitations I think my assessment of classmates work has been correct.

k) Taking into account my classmates limitations I think their assessment of my work has been correct.

General questions:

l) The use of the returnables has helped me to keep up with the subject.

m) This activity should not affect my final mark.

n) Returnables are a good study tool.

o) The experience overall has been positive.

Fig. 3 shows the mean value for each question in the survey from the answers of students classified by their degree, Degree on Computers Engineering and Degree on Telecommunications Engineering. From the picture it can be observed that students from both degrees share common opinions, and that for a majority of questions the mean value is greater than 7, that is, students agree with the sentence used in the question. From the four questions with a low mean

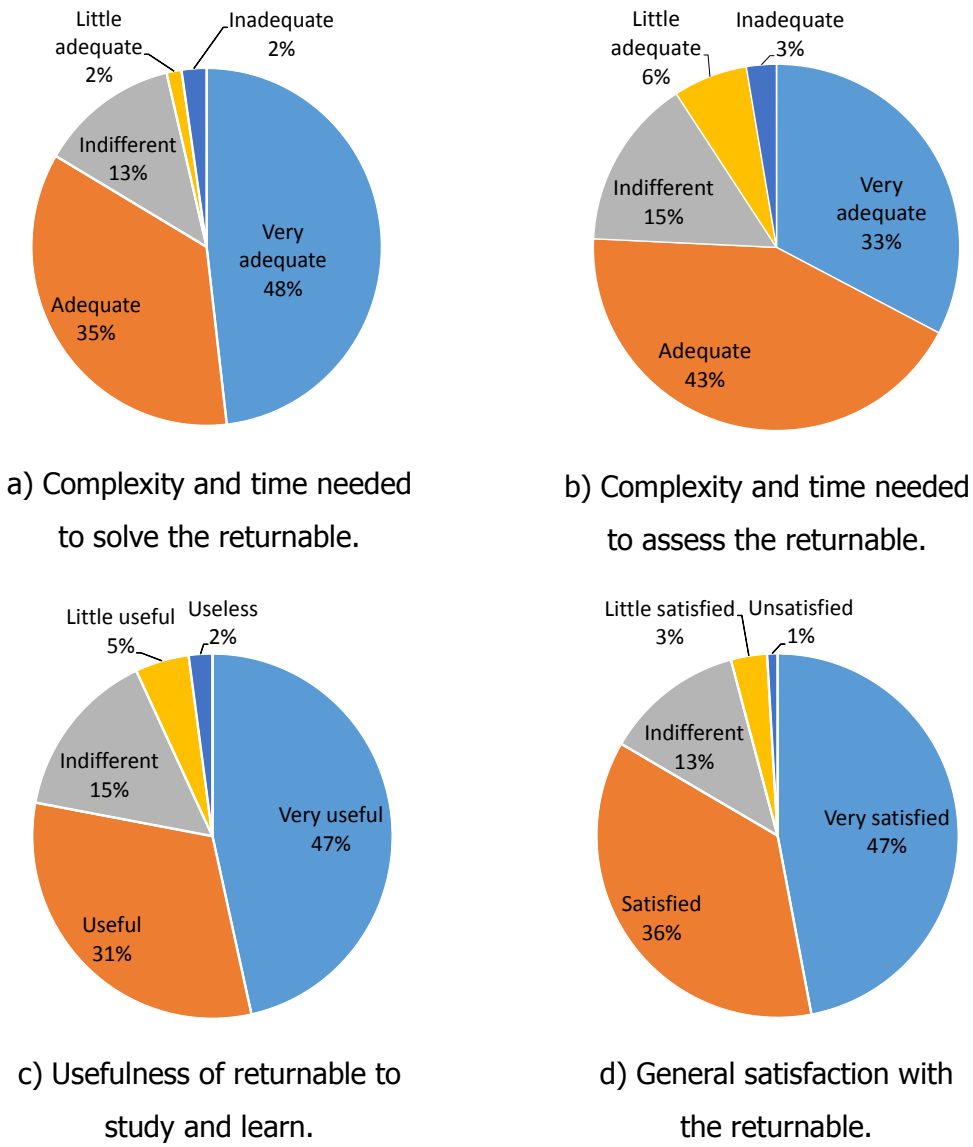

Fig. 4. Survey numerical results per group of questions.

(below 6, some even close to 3) three of them (questions *g*, *h*, and *m*) have a negative sentence. In these cases a low mean points to a high number of students satisfied with the use of returnables, or at least with the way the returnables have been used in this experience.

Taking into account the returnables have been used during the first semester of the first year of the degree, that most students are fresh university students, and that for most of them this is the first time they have to formally assess and correct the work of a classmate, the low results of question *i* are not surprising: students tend to think that assessment rules given with the returnable are of little use or at least difficult to use when assessing the work of their classmates. This conclusion comes not only from the numeric results from the questionnaire regarding question *i* but also from the free written comments in the survey.

Figs. 4 (a) to (d) depict the overall student satisfaction level grouping their answers in four global groups related to the adequacy of the experience, its usefulness and the student satisfaction level, with no classification by their degree this time. From these we can observe that more than 80% of students consider adequate time given and effort required to resolve and assess the returnables. It can also be observed that the use of the returnables has been useful to prepare the exams to almost 70% of the students, and that more than 80% is satisfied with the experience.

However it is worth noting that in chart of Fig. 4 (b) the percentage of "Adequate" sector is a 10% higher than in the others chart, with a clear transfer of students from the "Very adequate" group to "Adequate" group. This means that assessing and evaluating their classmates work represents a challenge for fresh students who have not been prepared for these tasks.

IV. Conclusions

The methodological change caused by the implementation of the new degrees in Computer Engineering and Telecommunication Engineering at UPV provides a clear opportunity to improve educational practices.

The teaching tool described in this paper is aimed to increase student work outside the classroom, motivate the students while raising their awareness about the importance and impact of their work.

By using returnables teachers manage to strengthen the results of homework and the learning process in a flexible and entertaining way. In addition, compared to more traditional learning models, student participation is encouraged.

The combination of returnable and peer assessment has significant advantages for both teachers and students, because i) it is almost guaranteed that students work outside the class to reinforce the work performed in the classroom; ii) each student works first in student mode and then works in teacher mode, thus doubling the work without doubling the effort; iii) responsibility is reinforced by involving students in the assessment process; iv) the students become familiar with the evaluation criteria.

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References

[1] Juan Carlos Cano, Jose Luis Poza, Salvador Petit, Marina Alonso, Pedro Yuste, Floreal Acebrón, Antonio Martí, Juan Luis Posadas, Vicente Atienza, Lenin Lemus, Francisco Rodríguez, "Fundamentos de Computadores. Grado en Ingeniería Informática. III Jornada de Innovación Docente. ETSInf. UPV. 2010.

[2] D.R. Krathwohl, B.S. Bloom, and B. Masia, Taxonomy of Educational Objectives: The Classification of Educational Goals - Handbook 2: Affective Domain, 1a ed., Longman, London, UK, July 1964.

[3] Robert Davies and Teresa Berrow, "An evaluation of the use of computer supported peer review for developing higher-level skills," Journal Computers & Education. Volume 30 Issue 1-2, Jan./Feb. 1998. Pages 111-115.

[4] John Hamer, Kenneth T. K. Ma, and Hugh H. F. Kwong, "A method of automatic grade calibration in peer assessment," In Proceedings of the 7th Australasian conference on Computing education (ACE '05), 2005.

[5] William J. Wolfe, "Online student peer reviews," In Proceedings of the 5th conference on Information technology education (CITC5 '04), 2004.

[6] Robert Davies and Teresa Berrow, "An evaluation of the use of computer supported peer review for developing higher-level skills," In Selected papers from the CAL 97 Symposium on Symposium (CAL '97), 1998.

[7] B.W. Ford, The Effects of Peer Editing/Grading on the Grammar-Usage and Theme-Composition Ability of College Freshmen, Dissertation Abstracts International, 33, 6687.

[8] J. M. K. MacAlpine, "Improving and Encouraging Peer Assessment of Student Presentations," Assessment & Evaluation in Higher Education, Vol. 24, Iss. 1, 1999.

[9] Yaqub Rafiq, Hazel Fullerton, "Peer Assessment of Group Projects in Civil Engineering," Assessment & Evaluation in Higher Education, Vol. 21, Iss. 1, 1996.

[10] Shirley E. Earl, "Staff And Peer Assessment Measuring An Individual's Contribution To Group Performance," Assessment & Evaluation in Higher Education, Vol. 11, Iss. 1, 1986

[11] Francis Lopez, Real, Yin, Ping Rita Chan, "Peer Assessment of a Group Project in a Primary Mathematics Education Course," Assessment & Evaluation in Higher Education, Vol. 24, Iss. 1, 1999.

[12] Obeua S. Persons, "Factors Influencing Students' Peer Evaluation in Cooperative Learning," Journal of Education for Business, Vol. 73, Iss. 4, 1998.

[13] Gehringer, Edward F, "Electronic peer review builds resources for teaching computer architecture," 2003 American Society for Engineering Education Annual Conference, Electrical & Computer Engineering Division, 2003.

[14] Miguel Riesco Albizu, Marián Díaz Fondón, "La revisión entre iguales como herramienta de aprendizaje y evaluación en la asignatura de sistemas operativos," Jenui 2007