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Online self-assessment with feedback and metacognitive knowledge

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Abstract The present work describes an experience of educational innovation in a university context. Its aim was to determine the relationship between students' frequency of use of online self-assessment with feedback and their final performance on the course, taking into account both learners' motivation and perceived usefulness of these resources for their learning process. Furthermore, we studied the relationship between metacognitive variables and academic performance and/or execution of activities aimed at learning the course content. To this end we created self-assessment material with the *Hot Potatoes* educational program and assessed the degree to which students took advantage of the tool, their satisfaction with it and their perceived knowledge, using ad hoc questionnaires. The results indicate better academic performance in those students that use interactive self-assessment. It should be pointed out that even students with low motivation levels made use of this teaching tool. Finally, a relationship was found between metacognitive variables and students' effort and performance. We discuss the need to include self-assessment in the curriculum, with a view to improving students' metacognitive knowledge.

Keywords Online self-assessment · Formative assessment · Metacognition · Self-regulation · Perceived learning · Academic performance · Motivation

Introduction

Learning via the Internet is an alternative that offers numerous advantages, such as ease of providing feedback (Collis et al. 2001), more flexible learning (Sherman 1998) and access to a

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broader student base (Plous 2000). The present paper focuses on online self-assessment, understood as a type of formative assessment, and its relationship to metacognitive knowledge.

To begin with we should clarify the concept behind the term 'formative assessment'. According to Scriven's (1967) classic typology, a clear distinction can be made between 'summative assessment' and 'formative assessment'. Summative assessment takes place at the end of the educational program, with measurement as its principal goal. Formative assessment, on the other hand, is carried out throughout the teaching-learning process, with the objective of monitoring the process and making any necessary improvements to the teaching program. In this type of assessment there is a mechanism of teacher–student interaction and dialogue, since it should consist in the management or coordination of the teacher's activities and the adaptation of learning by students.

Currently, some researchers defend an integrated assessment model, arguing that all assessments should be conceptualized as 'assessment for learning' (e.g., Kennedy et al. 2006). Moreover, in the context of the assessment of learning it is generally accepted that the feedback students receive from the teacher is a key supportive factor in the process of continuous improvement (Black and William 1998; Ricketts and Wilks 2002). Recently, Taras (2005) argued that all assessment begins with summative assessment (which is a judgment) and that formative assessment is the next step, when feedback to be used by the learner is added to the summative assessment. Therefore, it is not possible for assessment to be solely formative, a summative judgment necessarily having gone before.

Online self-assessment with feedback

"Self-assessment" is a widely used concept, and one which can involve very different notions and consequences for students. Boud and Brew (1995) suggest distinguishing between "self-testing", "self-rating" and "use of reflective questions". *Self-testing* involves students checking their performance against provided test items (with right and wrong answers) and provided criteria. *Self-rating* implies an appraisal by students of their present state of knowledge or achievement (with no right and wrong answers). *Reflective questions* are used to prompt learners to reflect on what they have studied and to be critical about their learning.

Online self-assessment is an important part of the e-learning process, and many tools are available for receiving and sending feedback. It is carried out via the Internet, in such a way that students can have access to self-assessment exercises where and when they like; at the same time, the teacher can access students' results, also via the web. One of the clearest advantages of this self-assessment system is that the exercises are corrected automatically and instantaneously, allowing immediate, precise and impartial feedback to the student's responses.

Another advantage of the use of self-assessment is its effect on students' learning process, since they carry out a process of 'self-testing' to assess their knowledge on a given subject. Moreover, not only is self-assessment useful as an assessment instrument, but when used prior to the study of a given topic or content area (Challis 2005) it can constitute an outstanding diagnostic tool for providing valuable information to the teacher about the student's previous knowledge.

It has been shown in numerous studies that interactive self-assessment tests can help to improve learning when students receive feedback about the results (Peat and Franklin 2002). Feedback should be formative (e.g., Taras 2005), permitting students to rate their knowledge and the gaps in it, and thus to regulate their learning. Teaching students to control their own learning process should be the ultimate goal of the feedback given by

tutors/teachers (Sadler 1989). Therefore, the effectiveness of self-assessment will depend to a large extent on the quality of the feedback provided to the student (Taras 2003).

Taras, one of the leading researchers in the field of self-assessment and its influence on students' performance, places particular emphasis on the importance of not giving grades for self-assessment tests, since they would serve only to block the intended supportive function of such exercises (Taras 2001, 2003). Refraining from giving grades at least until students finish the task will permit them to focus on their work with as little emotional interference as possible. Students should feel free to explore their knowledge and the gaps in it, being able to make errors without the fear that this will affect their final grades. It is in this respect that the teacher is of paramount importance, since self-assessment without feedback from the teacher/tutor would not be sufficient for students to become aware of their errors and the causes of them (Taras 2003).

In short, many frameworks justifying the use of self-assessment can be found in the literature. The self-assessment exercises with automatic feedback developed in the present study aimed to provide a learning tool to students, in order to improve their learning of Statistics, since students had to use a variety of learning strategies and higher-order thinking skills, and in sum, appraise their knowledge and orient their learning process.

Metacognition and self-assessment

Metacognition refers to a person's knowledge about his or her own cognition and about the control he or she has over it (Flavell 1976). Since the term 'metacognition' was coined it has been considered an essential element in the study of the teaching–learning process, because it is seen as the 'control centre' of the cognitive system. Brown (1987) explores this field more deeply, defining two broad and inter-related dimensions: knowledge of cognition (knowledge about oneself as a learner, about one's strategies and about when and how to use them) and regulation of cognition (planning, supervision and assessment of the regulatory processes of one's own learning). This is illustrated in Fig. 1.

The field of metacognition has given rise to a great quantity of publications, though it continues to be a somewhat confused one, without clear boundaries and closely linked to that of self-regulation. In this regard, Zulma (2006) established three types of relationship between the terms self-regulation and metacognition:

(a) Including the term regulation as a component of metacognition following the tradition of Flavell and Brown that comprises both a knowledge dimension and a regulation dimension; in these cases the term self-regulation is used to refer to the regulatory dimension of metacognition.

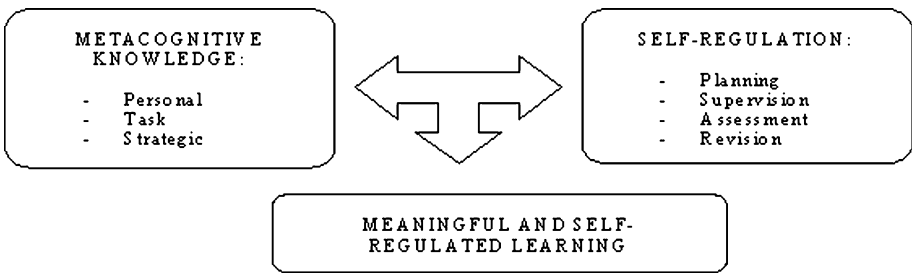

Fig. 1 Dimensions of metacognition and its influence on learning

(b) Treating them as synonyms; in these cases the true scope of the terms is generally assigned by the reader.

(c) Including both concepts in the self-regulated learning construct, following the line of Boekaerts (1999), Pintrich (2002, 2004) or Zimmerman (1995). This theoretical model is the one we follow in the present study, which defends the notion of self-regulation as a form of control of the action characterized by the integration of metacognitive knowledge, regulation of cognition and motivation. From this point of view, *self-regulated students* use cognitive, metacognitive and motivational strategies for meaningful learning, being capable of regulating and controlling the entire process. Such students are aware of their knowledge and skills, adjust their behaviors and activities to the study demands, are motivated to learn and are able to regulate their motivation (Pintrich 2004). Self-regulation of learning is fundamental for academic success, since this is related to high and intense investment of study time and to the strategic pattern of self-regulation employed (Rosario et al. 2005): self-regulating students know that their activity and involvement are crucial factors in academic success. As research on the self-regulation process in higher education has shown, students with higher academic achievement are self-regulated students (Nota et al. 2005; Williams and Hellman 2004).

In relation to metacognitive knowledge, the accuracy of self-knowledge—that is, having accurate perceptions and making accurate judgments about one's knowledge and skills—is relevant to learning (Pintrich 2002). Students who are unaware that they lack certain abilities or factual or procedural knowledge are unlikely to make sufficient effort to acquire or construct new knowledge. In view of this, we can affirm that learning is influenced, to a large extent, by the students' opinions of themselves. According to Pintrich (2002), teachers should help students to make more precise assessments of their own knowledge, so that they can orient their own behaviour accordingly and so that their self-knowledge is more in line with reality. In other words, we do not advocate that teachers attempt to boost students' self-esteem (a completely different construct from self-knowledge) by providing them with positive, but false, inaccurate, and misleading feedback about their strengths and weaknesses.

In Flavell's model self-assessment plays a key role in his conception of metacognition. Metacognitive skills are generally divided into two types: self-assessment (the ability to assess one's own cognition) and self-management (the ability to manage one's further cognitive development). According to the research on self-assessment, learners who are skilled in metacognitive self-assessment and are therefore aware of their abilities are more strategic and perform better than those who are unaware (Imel 2002).

Therefore, self-assessment and metacognition would be closely bound up with one another, since the ultimate goal of self-assessment is that students learn to self-assess their knowledge and to self-regulate their learning process, thus increasing their autonomy and intrinsic motivation. Self-assessment facilitates better control over one's own cognitive activities: students must succeed in understanding which strategies they should use in each task and when and how to use them (Brookhart 2001), as well as being able to identify irrelevant information and discard it (Quinn and Reid 2003). Teaching activity, therefore, will be aimed at training students to acquire greater autonomy and control in the constructive process that characterizes learning.

Assessment of metacognitive knowledge

There is a considerable degree of difficulty involved in assessing the constructs associated with the process of self-regulation of learning, as they are not externally observable, making

it necessary to utilize self-report-type instruments. For example, in studies on perceived learning (Rovai et al. 2009), students are asked questions about the extent to which they feel they have learned something in a given subject or are able to use specific skills as the result of the content learned on the course. Normally, questions are put to them at the end of the teaching-learning process, so that they can estimate what they have learned. However, it would be more appropriate to make a pre-post comparison of perception of knowledge of the specific content included in the teaching program of each subject area.

In the present project we have considered it of special interest to involve the students actively, focusing on them and providing them with a space so that they can give expression to perceptions of their progress in the subject area. Through the initial assessment of the perception of knowledge on a given topic before it is dealt with in class/lectures, it is attempted to draw up an *X-ray* or *map* of the distinctive traits of an individual or a group. According to the constructivist perspective, an important aspect of initial assessment would be the identification and activation of previous knowledge on which learning can be built (creating a 'scaffold'), allowing the development of more meaningful learning. Today there is broad acknowledgement of the value of meaningful learning, which involves the possibility of attributing meaning to what must be learned on the basis of what is already known (Ausubel 1983), thus favoring more 'durable' learning.

On the other hand, assessing students' perception of a subject after it has been covered in class or lectures helps students to become aware of their own perception of the work done and which aspects they are not sufficiently clear about, at the same time as helping the teacher to identify the points not adequately understood by the students. Pickard (2007) argues that the development of students' metacognitive capacities can be helped by asking them to note the amount of effort they have had to invest in each subject/module/topic. In this way they will become aware of the effort they have made, and that sometimes they have not worked enough, and of how this is reflected in their final performance (Marzano et al. 2001). It is considered, moreover, that this will motivate and stimulate participation in the students, who will feel acknowledged, this in turn leading, in Rotger's (1990) view, to better results.

Objectives

- To assess the degree to which students take advantage of and are satisfied with the self-assessment tool, without offering any additional incentive to use it (following the arguments of Taras 2001, 2003), so as to determine their intrinsic motivation in relation to the educational resource assessed. Likewise, we set out to ascertain whether those students who were most highly motivated vis-à-vis the study material were those who carried out most self-assessment activities, since this is one of the factors that most influences meaningful learning (Graham and Weiner 1996; Pintrich and Schunk 2002).
- To verify whether the more interactive self-assessment exercises students do the better the grades they obtain (Lowry 2005; Martínez and Moreno 2007). It is posited that students who adequately apply themselves to the subject will be those who make most use of the self-assessment resource, and who will obtain better results.
- To explore the relationship between different metacognitive variables (perception of previous knowledge and perception of final knowledge) and academic performance and/or making use of activities oriented to learning of the relevant material. It is interesting to determine whether students with a perception of less previous knowledge are those that perform most learning-oriented activities. Being aware of what one does

not know can be crucial for re-orienting the study method, especially at a point where such information is relevant for continuing one's learning process and completing it successfully (Carrasco et al. 2005). Moreover, we hypothesized that the greater the student's activity, the more the perception of knowledge increases (Gómez Alvarez 2006); consequently, this variable may be a good indicator of final performance.

Method

Participants

The present study on educational innovation was carried out with a group on the 'Data Analysis I' course of the Psychology degree ($N = 116$) at the University of the Basque Country (Spain). This subject is taught in the first year of the degree and is mandatory. Students received 56 h of classes (32 lectures, 9 practical classes with all students together, and 15 computer practice sessions in small groups) for one semester. Attendance at lectures was 73%. At lectures and practical classes there were usually approximately 85 students, while at computer practice there were usually 20 students. The self-assessment exercises were done voluntarily outside of class time.

Material

Taking into account the typology of "self-assessment" explained by Boud and Brew (1995), the exercises used in this experience could be understood as "self-testing" tasks, but with feedback. These exercises assessed statistical knowledge and skills to develop with a data-analysis program. They were linked to conceptual recall, recognition and problem-solving. Students had to solve small problems rather than recall isolated pieces of information. A wide range of interactive self-assessment tasks was employed, using the *Hot Potatoes*™ program (Version 6) from *Half-Baked Software Inc*. The various exercises (multiple-choice, matching exercises, short answers, incomplete sentences and crosswords) were posted on the Internet once the teaching unit had been explained in class, and remained there until the final exam. For each unit of the educational program a pool of 25 multiple-choice items (125 items in total) was drawn up. There was also a final test involving some revision exercises (short answers, incomplete sentences and crosswords) for each unit, which need further elaboration from students. The marks obtained in each unit and in the final test were given to the students. The multiple-choice questions had feedback for each of the options that could be selected, indicating what was correct/incorrect with regard to the particular answers chosen. When the answer was incorrect, hints were available for prompting the student to think more deeply about the problem or to recall certain facts, rather than simply pointing out the specific error that may have been made. Students could repeat the exercises as many times as they wanted.

Ad hoc questionnaires on knowledge perception were designed. These questionnaires were administered to the students before (*initial perception*) and after (*final perception*) each teaching unit, so that they could rate on a scale of 0–10 their knowledge about each section and subsection of the thematic block. Based on the difference between final and initial perception, the *perceived learning* variable was established.

Finally, two more questionnaires were drawn up. The first was used to estimate student effort, assessed according to the time spent on each unit. Students were required to estimate

how much time they had devoted to each teaching unit (attendance at lectures, studying, and use of the Internet). The second questionnaire was designed to assess students' satisfaction with regard to the self-assessment tool, to which they had to respond, anonymously, at the end of the semester. The goal of this questionnaire was to measure, using 10 Likert-scale items (from 1, Totally disagree, to 5, Totally agree), both user-friendliness of the educational software (for example, "*Ease of use of the program*") and perceived learning (for example *"It serves as a complementary learning resource"*).

Procedure

We used a non-experimental research methodology, since the groups corresponding to the independent variable *Self-assessment* (users vs. non-users) could not be assigned at random for ethical reasons. Each student could decide freely between doing the self-assessment exercises proposed by the teacher or not, bearing in mind that use of the tool gave no advantage in terms of an automatic increase in final grade. The students received training about the self-assessment tool and were given an explanation of the project's aim, in order to increase their motivation as much as possible.

The most relevant variables measured were learning (assessed by final grades), metacognitive variables (assessed by knowledge perception) and student effort (estimated by the students).

Furthermore, in relation to use of the self-assessment tool, four variables were measured: frequency of system entry, number of exercises performed, total time invested (minutes) and mean score—all data that could be obtained directly through *Hot Potatoes*, as an additional feature of the program.

Finally, by way of a complement we assessed motivation in relation to the study material, taking into account the number of voluntary tasks (reading and analyzing scientific documents, creating problem statements, collecting data, statistical analysis and interpretation of data) carried out throughout the course. Doing such tasks gave students a slight increase in their final grade (maximum 15%), though this increase was awarded once the exam had been passed.

Results

Students' satisfaction with the self-assessment tool

Students' level of use of the tool was quite high (46%) with respect to the total number of students on the course, bearing in mind that it was a voluntary activity to be done outside of lecture time and without additional incentive.

In the satisfaction questionnaire there were some items related to the program's user-friendliness and others related to perceived learning. Figure 2 shows the mean scores for some issues raised in the satisfaction questionnaire. On the basis of these scores it can be concluded that this formative assessment tool is highly rated among students in both aspects.

Self-learning through self-assessment and academic performance

One of the most relevant goals of this research was to determine whether frequency of use of the self-assessment tests was related to academic performance (assessed by means of

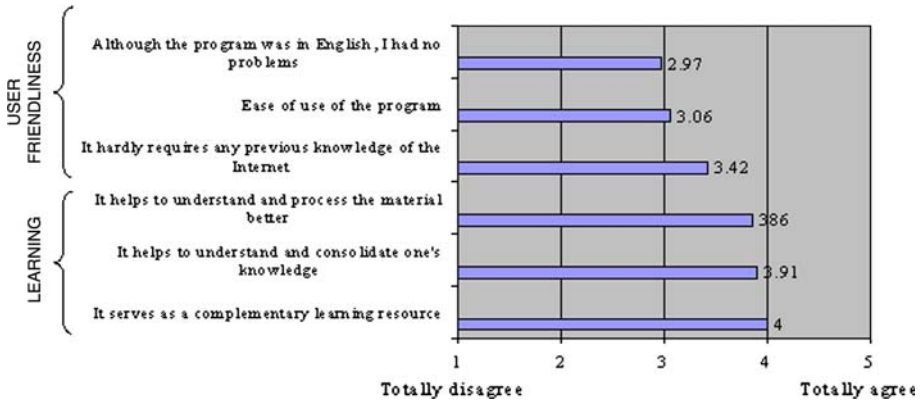

Fig. 2 Satisfaction level of students who used the self-assessment tool

final grade in the subject). The results indicate that frequency of doing the self-assessment exercises correlates positively with academic performance [$r\ (81) = 0.24$; $P < 0.05$], signifying that the more self-assessment exercises students do, the better their final grade. Moreover, and logically, the number of exercises performed is also associated with academic performance [$r\,(81) = 0.25$; $P < 0.05$]. Taking into account only those students that used the tool, a significant correlation was also found between time spent on the exercises and final grade [$r\ (24) = 0.42$; $P < 0.05$],[1] but in this case it was necessary to control the extraneous variable 'exam sitting' (February, June or September), since it is possible that students with more problems in the subject need more time to carry out the exercises, without this translating into improved performance with respect to the group. A linear regression analysis revealed that mean score obtained in the self-assessment exercises was a highly significant predictor of final grade ($\beta = 0.45$, $P = .01$), accounting for 20% of the variance in final grade.

Participants were classified as users or non-users of the tool depending on whether they had at least completed the exercises from one thematic block (27%). Results indicate that academic performance of students who used the self-assessment tool [$\overline{X} = 6.31$; SD = 2.3] is not better than those who did not use it [$\overline{X} = 5.31$; SD = 2.3], $t\ (80) = -1.86$; $P = 0.06$], but the difference of means is 1 point, which almost reaches significance. In order to determine whether this difference was due to the nature of the students themselves (better students), we compared the performance of the two groups (those previously categorized as users/non-users) in a similar subject (Psychobiology I), in which no interactive self-assessment tasks were offered. The results show that academic performance of the students who used the self-assessment tool [$\overline{X} = 5.57$; SD = 2.2] is equal to that of those who did not use it [$\overline{X} = 5.08$; SD = 2.04], $t\,(59) = -0.832$; $P = 0.41$. The difference between the two groups is far from significant, so that the differences found in the 'Data Analysis I' subject may not be attributable to the nature of the students (better/poorer students).

With the aim of determining which type of students benefited most from self-assessment exercises, we drew up Fig. 3. This figure shows that a notable majority of students who obtained higher grades (very good and excellent) made use of the *Hot Potatoes* tool.

[1] The system did not show scores obtained or time invested in the self-assessment exercises if the learner failed to finish all items in an exercise. Thus, the number of participants was lower in the respective analysis.

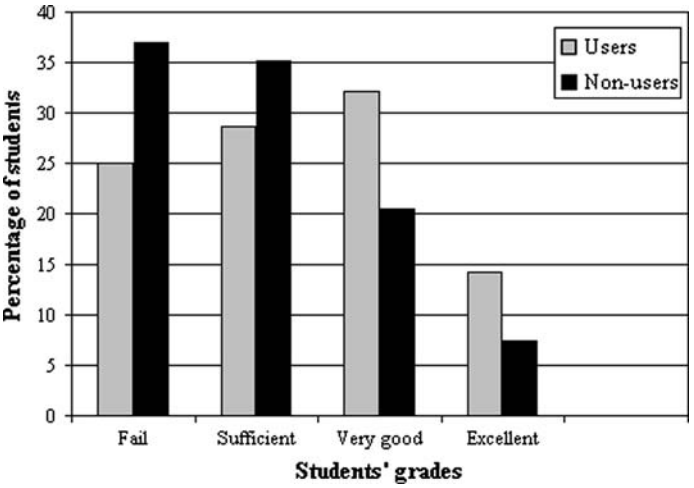

Fig. 3 Students' grades according to use of the self-assessment tool ($n = 82$)

As far as motivation is concerned, the use of hierarchical cluster analysis in the present study proved fruitful in identifying three subgroups of students with differentiated motivational patterns, $F\ (2, 81) = 29.46$; $P < 0.001$. Subsequently, in an ANOVA analysis, the motivation factor was found to be significant for use of the self-assessment tool, $F\ (2, 81) = 4.5$; $P < 0.05$. According to Scheffé analysis, the least motivated group ($\overline{X} = 5.52$, $n = 27$) used the assessment tool less frequently than the most motivated group ($\overline{X} = 21.7$, $n = 10$), $P < 0.05$. Moreover, use of the self-assessment tool was greater in the most motivated group than in the medium-motivation group ($\overline{X} = 7.35$, $n = 45$), $P < 0.05$. However, as can be seen in Fig. 4, the least motivated students also used the self-assessment tool at some time, since almost 50% of students who did no other voluntary activity tried this formative assessment resource.

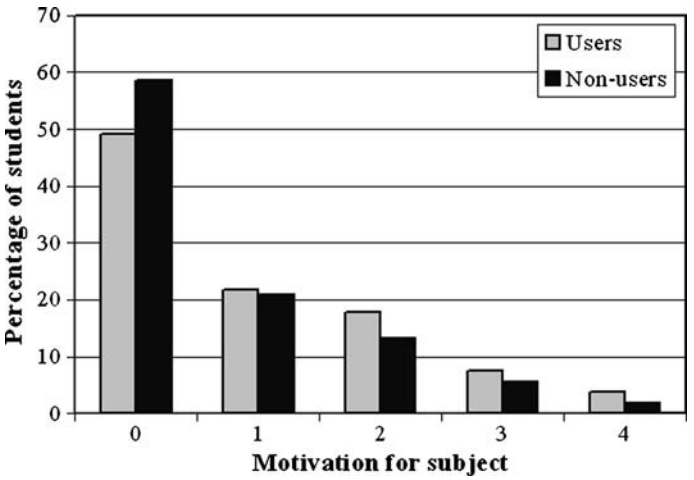

Fig. 4 Students' motivation according to use of the self-assessment tool ($n = 106$)

Table 1 Correlations for meta-cognitive variables and academic performance with time invested in the different activities

Activities done	Initial perception ($n = 52$)	Final perception ($n = 63$)	Perceived learning ($n = 52$)
Lectures	−0.17	0.30*	0.29*
Internet	−0.02	0.20	0.13
Study	0.09	0.32*	0.12
Total activity	0.05	0.33**	0.15

* The correlation is significant at the 0.05 level (bilateral)

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

Meta-cognitive variables and students' activity

One of the goals of the present work was to explore the relationships between the meta-cognitive variables and activities oriented to learning the subject content. As Table 1 shows, interesting correlations were found between the meta-cognitive variables (initial perception, final perception and learning) and time invested by students in the different study activities for the subject.

It can be seen that as far as the initial assessment is concerned, the correlations are non-significant. This would suggest that students' initial perception from greater to lesser knowledge about a topic is not related to subsequent greater or lesser activity. However, as regards the final assessment, it should be pointed out that the significant positive correlations are found between final perception and student effort. With regard to perceived learning, only attendance at lectures presents a moderate significant correlation. In general, it should be highlighted that in the final assessment [$\overline{X} = 5.01$; SD = 1.1] the scores were significantly higher than those of the initial assessment [$\overline{X} = 1.8$; SD = 1.38], $t\ (51) = -15.07$; $P < 0.001$.

With respect to the different metacognitive variables, on checking for any type of relationship between them and academic performance we found that final perception was moderately related to academic performance [$r\ (44) = 0.31$; $P < 0.05$]. However, final grade showed no relationship with either initial perception [$r\ (55) = -0.22$; $P = 0.09$] or student's effort [$r\ (44) = -0.05$; $P > 0.05$].

Finally, it should be mentioned that motivation toward the study material correlates positively with study time outside the classroom (self-learning) [$r\ (61) = 0.25\ P < 0.05$], and with frequency of use of Internet for studying the subject [$r\ (60) = 0.33$; $P < 0.01$].

Discussion

The present study aimed, first, to assess the degree to which students take advantage of and are satisfied with the self-assessment tool created, second, to reveal whether the more interactive self-assessment exercises students do the better the marks they obtain, and third, to examine the relationships among metacognitive variables. These aims would be achieved through the use of activities oriented to learning of the subject and academic performance. The results obtained showed that the self-assessment tool was well received by students. Overall, our findings suggest a positive relation between the use of self-assessment and academic performance. The results obtained partially confirmed our

hypothesis with regard to metacognitive variables, since students' initial perception was not linked to their subsequent time investment in the subject in question. Nevertheless, students' final perception was positively correlated to attendance at lectures and time spent studying outside of lectures. Moreover, and surprisingly, the results also suggested that there was no relationship between students' effort in studying the subject and their academic performance.

In this study, self-assessment material was prepared with the aim of carrying out formative assessment via Internet. Although research shows that, initially, students faced with new teaching strategies tend to show some degree of reticence (e.g., Oliver and McLoughlin 2001), the tool employed in the present study was well accepted. The results indicate a high level of satisfaction among students with regard to the self-assessment tool presented, it being identified as a complementary learning resource that helps them consolidate their knowledge. Moreover, it is not only those students who showed themselves to be motivated toward the subject that use the interactive self-assessment tool, but also those who do not feel inclined to carry out other types of voluntary task, suggesting that it is an attractive tool which students perceive as useful and valuable. The value component of student motivation refers to the student's interest in the task itself. Our results suggest that self-assessment users have shown an intrinsic interest in the exercises, since the reason for using them was not the grade. Pintrich and De Groot (1990) found that students who were motivated to learn (and not just to get good grades) and perceived their tasks as interesting and important were more cognitively engaged in trying to learn.

We hypothesized that the relationship between the use of the self-assessment tool and final performance on the course would be positive. As expected, the results indicate better academic performance in those students who make use of interactive self-assessment for learning the content of the subject area analyzed. However, this does not necessarily mean that use of the system directly improves academic performance, since we were unable to use an experimental methodology that would lead us to such causal and firm conclusions, even though some statistical analyses, such as regression and analysis of variance, can be used to make predictions. In any case, it would seem that interactive self-assessment can be used to motivate students and increase their interest in the study of subjects such as Statistics (which are perceived as difficult by students and generate anxiety and reluctance in many of them), since a considerable proportion of students with "low motivation to learn" (who did not participate in voluntary and rewarded tasks) took advantage of the self-assessment exercises, even though they were not awarded extra points for this. These results suggest that, apart from students' motivation to learn, there are other factors which explain why some students use the self-assessment tool and others do not, which could include (among others) the possibility of access to Internet outside of university, level of skill with ICTs (Information and Communication Technologies), perceived usefulness of the tool, or anxiety about the tool. However, further research is needed to identify a user profile.

However, motivation, more than a pre-requisite, may be a mediator between learning conditions, learning strategies and academic performance (McKeachie et al. 1986). Teaching activities should stimulate students' interest, which will be related to their cognitive engagement. Teachers should not ignore the impact of teaching/learning climate (the curriculum, teacher–student interaction, teaching and assessment methods, course structure or subject area) on students' learning and achievement (Biggs and Tang 2007). As these authors argue, teachers should ensure that academic activities are worthwhile and meaningful for learners so that they build up a feeling of "ownership" over their learning, providing the motivation that leads to good learning.

In the present study certain metacognitive variables were analyzed, such as students' perception of their learning, through a series of questionnaires in which they had to rate their level of knowledge about diverse aspects of a thematic unit, before beginning and immediately after finishing the lectures on that topic. Contrary to expectations, students' initial perception was not associated with their subsequent commitment to the subject in question. It is likely that students with a high level of initial knowledge are 'good' students in general, have high expectations with regard to academic performance, and therefore work more. However, students with less previous knowledge or with problems in mathematics may be the least motivated, and their dedication to the subject might not be continuous, but rather concentrated towards the end of the course. In this regard it should be pointed out that the information gathered about students' activity reflects how well they followed the subject, and not their total effort throughout the course. Also, on interpreting the results on students' commitment, some caution is necessary because they are based on subjective assessments by the students themselves. This assessment might reflect an overestimation, as students may try to give a good image of themselves, even though their anonymity was guaranteed through the use of codes to identify them on the questionnaires.

As far as students' final perception is concerned, this was positively correlated to attendance at lectures and time spent studying outside of lectures. It is logical that those students who attend lectures most often and study most are those who perceive having learned most over the course of the teaching unit, and this indeed confirms the results obtained by Gómez Álvarez (2006). Moreover, final perception was positively related to academic performance. The results of Honkimaki et al. (2004) are congruent with this finding, as they verify that students' perceptions of their learning experiences and assessments of their own learning correlate with their teachers' 'objective' assessment.

In the line of Martínez and Moreno's (2007) observations, in the present study the time students invested in working on the subject did not correlate with their performance in the summative assessment. This could be due to the fact that students' initial level of knowledge and expectations are quite disparate, and it may be that the effort they make does not correspond to their actual dedication to the subject needed for attaining acceptable levels of learning. Some authors recommend training students more in the development of metacognitive capacities, so that they learn to self-assess their knowledge as well as plan and self-regulate their learning process in the direction of the goals set, thus taking better advantage of their study time (e.g., Pintrich 2002). First of all, because it has been verified empirically that students tend to overestimate their ability to do tasks (Glenberg et al. 1982; Vadhan and Stander 1994), and often defectively perceive their understanding (Moore et al. 2005). For example, Vadhan and Stander (1994) found a negative correlation between university students' grades and their own estimations about their grades, reflecting a deficit in their metacognitive skills. In the psychological context, Mabe and West (1982) carried out a meta-analysis, finding the mean correlation between self-estimations and level of performance to be 0.29. Nevertheless, some authors argue that many studies have methodological weaknesses, because it is not clearly determined whether teachers and students use common standards and criteria when assessing learning (Boud and Brew 1995), self-grading is often not defined, or very different scales and methods are used (Falchikov 2005). And such training is also recommended because, as numerous studies have shown, there is a favorable effect of training in metacognitive strategies in different areas of the curriculum: in reading (Campione 1987); in writing (Higgins et al. 1992); in the use of graphics and maps (Schofield and Kirby 1994); and in problem-solving (Bielaczyc et al. 1995).

Self-assessment, as a tool for improving self-regulation, has been defined as "the involvement of students in identifying standards and/or criteria to apply to their work" (Boud 1991). Some experimental research studies illustrate how students' achievement improves when they understand learning objectives and assessment criteria, because this allows them to reflect on their performance (Boston 2002; Fontana and Fernandes 1994). McDonald and Boud (2003), using experimental methodology, demonstrated that self-assessment training can have an impact on student performance. These researchers argue that the use of self-assessment training as part of the curriculum could provide skills students will need as lifelong learners after school. Falchikov and Boud (1989) also suggest that it may be more useful to develop ways in which systematic formative self-assessment activities can be incorporated into courses to improve students' skills in making sensitive and aware judgments on their own work. We agree with Falchikov (2005) in the claim that "the main benefits of involving students in self-assessment reside in the potential for improving learning and stimulating personal and academic development" (p. 189). Although our innovation experience did not consist in asking students to judge their own performance against their own assessment criteria, we believe the self-assessment exercises developed may be useful as a prelude to students' subsequent self-judgment of their achievement.

In sum, online self-assessment with feedback exercises could aid learning, perhaps via metacognitive knowledge. Therefore, it may be advantageous for teachers to include self-assessment in the curriculum, since it could contribute to learning, given that students would be more aware of their knowledge level, and would spontaneously engage in self-assessment more often (Roll et al. 2006). Self-assessment tasks are an effective way of achieving self-regulation, as are activities that encourage reflection on the learning progress. Indeed, teachers' feedback responses need to be interpreted, constructed and internalized by the student if they are to have a significant influence on subsequent learning (Nicol and McFarlane-Dick 2006).

In future research it would be interesting to verify whether the online self-assessment tool also serves to improve students' diverse metacognitive skills, leading to better regulation of study, and whether, in line with the suggestions of Pickard (2007), the fact of requesting students to take note of the time devoted to each study activity aids their metacognition.

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References

Ausubel, N. H. (1983). *Psicología educativa: Un punto de vista cognoscitivo*. México: Trillas.

Bielaczyc, K., Pirolli, P. L., & Brown, A. L. (1995). Training in self-explanation and self-regulation strategies: Investigating the effects of knowledge acquisition activities on problem solving. *Cognition and Instruction, 13*, 221–252. doi:10.1207/s1532690xci1302_3.

Biggs, J., & Tang, C. (2007). Setting the stage for effective teaching. In J. Biggs & C. Tang (Eds.), *Teaching for quality learning at University* (3rd ed., pp. 31–59). England & NY: Society for Research into Higher Education & Open University Press.

Black, P., & William, D. (1998). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 80*(2), 139–144.

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research, 31*, 445–457. doi:10.1016/S0883-0355(99)00014-2.

Boston, C. (2002). The concept of formative assessment. Practical assessment. *Research Evaluation*, *8*(9), http://PAREonline.net/getvn.asp?v=8&n=9 Accessed 6 Aug 2008.
Boud, D. (1991). *Implementing student self-assessment. HERDSA green guide* (2nd ed.). Sydney: HERDSA.
Boud, D., & Brew, A. (1995). Developing a typology for learner self assessment practices. *Research and development in Higher Education, 18*, 130–135.
Brookhart, S. M. (2001). Successful students' formative and summative use of assessment information. *Assessment in Education, 8*(2), 153–169.
Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In E. Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65–116). Mahwah, New Jersey: Erlbaum.
Campione, J. C. (1987). Metacognitive components of instructional research with problems learners. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation and understanding* (pp. 117–140). Hillsdale: LEA.
Carrasco, A., Gracia, E., & de la Iglesia, C. (2005). Las TIC en la construcción del Espacio Europeo de Educación Superior. Dos experiencias docentes en Teoría Económica. *Revista Iberoamericana de Educación, 36*, 1–16.
Challis, D. (2005). Committing to quality learning through adaptive online assessment. *Assessment & Evaluation in Higher Education, 30*(5), 519–527. doi:10.1080/02602930500187030.
Collis, B., De-Boer, W., & Slotman, K. (2001). Feedback for web-based assignments. *Journal of Computer Assisted Learning, 17*, 306–313. doi:10.1046/j.0266-4909.2001.00185.x.
Falchicov, N., & Boud, D. (1989). Student self-assessment in higher education: A meta-analysis. *Review of Educational Research, 59*(4), 395–430.
Falchikov, N. (2005). *Improving assessment through student involvement. Practical solutions for aiding learning in higher and further education*. London: Routledge.
Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231–235). Hillslade, New Jersey: Lawrence Erlbaum.
Fontana, D., & Fernandes, M. (1994). Improvements in mathematics performance as a consequence of self-assessment in Portuguese primary-school pupils. *The British Journal of Educational Psychology, 64*, 407–417.
Glenberg, A. M., Wlkinson, A. C., & Epstein, W. (1982). The illusion of knowing: Failure in the self-assessment of comprehension. *Memory & Cognition, 10*, 579–602.
Gómez Alvarez, L. (2006). *Respeto por los estilos de aprendizaje y otros principios de práctica docente efectiva: Modelo para curso on-line centrado en el estudiante*. Paper presented at II Congreso Internacional de Estilos de Aprendizaje, Chile.
Graham, S., & Weiner, B. (1996). Theories and principles of motivation. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 63–84). New York: Simon and Schuster Macmillan.
Higgins, L., Flower, L., & Petraglia, J. (1992). Planning text together: The role of critical reflection in student collaboration. *Written Communication, 9*(l), 48–84. doi:10.1177/0741088392009001002.
Honkimaki, S., Tynjala, P., & Valkonen, S. (2004). University students' study orientations, learning experiences and study success in innovative courses. *Studies in Higher Education, 29*(4), 431–449. doi:10.1080/0307507042000236353.
Imel, S. (2002). *Metacognitive skills for adult learning. Trends and issues alert no 39*. Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education.
Kennedy, J. K., Sang, J. C. K., Wai-ming, F. Y., & Fok, P. K. (2006). *Assessment for productive learning: Forms of assessment and their potential for enhancing learning*. Paper presented at the 32 Annual Conference of the International Association for Educational Assessment, Singapore.
Lowry, R. (2005). Computer-aided self assessment—an effective tool. *Chemistry Education Research and Practice, 6*(4), 198–203.
Mabe, P. A., & West, S. G. (1982). Validity of self-evaluation of ability: A review and meta-analysis. *The Journal of Applied Psychology, 67*, 280–296. doi:10.1037/0021-9010.67.3.280.
Martínez, R. J., & Moreno, R. (2007). Validity of academic work indicators in the projected European Higher Area. *Higher Education, 53*, 739–747. doi:10.1007/s10734-005-4507-4.
Marzano, R. J., Norford, J. S., Paynter, D. E., Pickering, D. J., & Gaddy, B. B. (2001). *Handbook for classroom instruction that works*. Alexandria, VA: Association for Supervision and Curriculum Development.
McDonald, B., & Boud, D. (2003). The impact of self-assessment on achievement: The effects of self-assessment training on performance in external examinations. *Assessment in Education, 10*(2), 209–220. doi:10.1080/0969594032000121289.
McKeachie, W. J., Pintrich, P. R., Lin, Y., & Smith, D. (1986). *Teaching and learning in the college classroom: A review of the research literature*. Ann Arbor, MI: The University of Michigan (National Center for Research to Improve Postsecondary Teaching and Learning [NCRIPTL]).

Moore, D., Lin-Agler, L., & Zabrucky, K. M. (2005). A source of metacomprehension inaccuracy. *Reading Psychology: An International Journal, 26*, 251–265. doi:10.1080/02702710590962578.

Nicol, D., & McFarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31*(2), 199–218. doi:10.1080/03075070600572090.

Nota, L., Sorei, S., & Zimmerman, B. J. (2005). Self-regulation and academia and resilience: A longitudinal study. *International Journal of Educational Research, 41*, 198–251. doi:10.1016/j.ijer.2005.07.001.

Oliver, R., & McLoughlin, C. (2001). Tools for the teacher. In F. Lockwood & A. Gooley (Eds.), *Issues and innovations in distance education* (pp. 138–149). London: Bogan Page.

Peat, M., & Franklin, S. (2002). Supporting student learning. The use of computer-based formative assessment modules. *British Journal of Educational Technology, 33*(5), 515–523. doi:10.1111/1467-8535.00288.

Pickard, M. J. (2007). The new Bloom's taxonomy: An overview for family and consumer sciences. *Journal of Family and Consumer Sciences Education, 25*(1), 45–55.

Pintrich, P. R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. *Theory into Practice, 41*(4), 220. doi:10.1207/s15430421tip4104_3.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16*(4), 385–407.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33–40. doi:10.1037/0022-0663.82.1.33.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education: Theory, research and applications.* Englewood Cliffs, NJ: Prentice Hall Merrill.

Plous, S. (2000). Tips on creating and maintaining an educational World Wide Web site. *Teaching of Psychology (Columbia, Mo.), 27*, 63–70. doi:10.1207/S15328023TOP2701_13.

Quinn, D., & Reid, I. (2003). *Using innovative online quizzes to assist learning*. http://ausweb.scu.edu.au/aw03/papers/quinn/paper.html. Accessed 6 Aug 2008.

Ricketts, C., & Wilks, S. J. (2002). Improving student performance through computer-based assessment: Insights from recent research. *Assessment & Evaluation in Higher Education, 27*(5), 475–479. doi:10.1080/0260293022000009348.

Roll, I., Aleven, V., McLaren, B. M., & Koedinger, K. R. (2006). Designing for metacognition—applying cognitive tutor principles to the tutoring of help seeking. *Metacognition and Learning, 2*(2–3), 125–140. doi:10.1007/s11409-007-9010-0.

Rosario, P., Núñez, J. C., González-Pienda, J. A., Almeida, L., Soares, S., & Rubio, M. (2005). El aprendizaje escolar examinado desde la perspectiva del 'Modelo 3P' de J. Biggs. *Psicothema, 17*(1), 20–30.

Rotger, B. (1990). *Evaluación formativa*. Madrid: Cincel.

Rovai, A. P., Wighting, M. J., Baker, J. D., & Grooms, L. D. (2009). Development of an instrument to measure perceived cognitive, affective, and psychomotor learning in traditional and virtual classroom higher education settings. *The Internet and Higher Education, 12*, 7–13. doi:10.1016/j.iheduc.2008.10.002.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*, 119–144. doi:10.1007/BF00117714.

Schofield, N. J., & Kirby, J. R. (1994). Position location on topographical maps: Effects of task factors, training and strategies. *Cognition and Instruction, 12*, 35–60. doi:10.1207/s1532690xci1201_2.

Scriven, M. S. (1967). The methodology of evaluation. In: R. W. Tyler, R. M. Gagne & M. Scriven (Eds.), *Perspectives of curriculum evaluation*. AERA Monograph Series on Curriculum Evaluation, 1. Chicago: Rand McNally.

Sherman, R. C. (1998). Using the World Wide Web to teach everyday applications of social psychology. *Teaching of Psychology (Columbia, Mo.), 25*, 212–216. doi:10.1207/s15328023top2503_15.

Taras, M. (2001). The use of tutor feedback and student self-assessment in summative assessment tasks: Towards transparency for student and for tutors. *Assessment & Evaluation in Higher Education, 26*(9), 605–614. doi:10.1080/02602930120093922.

Taras, M. (2003). To feedback or not to feedback in student self-assessment. *Assessment & Evaluation in Higher Education, 28*(5), 549–565. doi:10.1080/02602930301678.

Taras, M. (2005). Assessment-summative and formative—some theoretical reflections. *British Journal of Educational Studies, 53*(4), 466–478. doi:10.1111/j.1467-8527.2005.00307.x.

Vadhan, V., & Stander, P. (1994). Metacognitive ability and test performance among college students. *The Journal of Psychology, 128*, 307–309.

Williams, P. E., & Hellman, C. M. (2004). Differences in self-regulation for online learning between first- and second-generation college students. *Research in Higher Education, 45*(1), 71–82. doi:10.1023/B:RIHE.0000010047.46814.78.

Zimmerman, B. (1995). Self-regulation involves more than metacognition: A social cognitive perspective. *Educational Psychologist, 30*(4), 217–221. doi:10.1207/s15326985ep3004_8.

Zulma, M. (2006). Aprendizaje autorregulado: El lugar de la cognición, la metacognición y la motivación. *Estudios Pedagógicos, 32*(2), 121–132.