Assessing student workload in Problem Based Learning: Relationships among teaching method, student workload and achievement. A case study in Natural Sciences

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**Abstract**

This study examines student workload after a change in teaching style from lecture to Problem Based Learning and Cooperative Learning, and its relationship with student outcomes. Results show that the change clearly overloads students if it is not adequately planned and monitored. Marks, drop-outs and attendance were markedly better with the new instruction method, but also with a higher workload. The main conclusion is that calculating student workload in terms of hours is very important, but especially when implementing a change in teaching style.

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1. Introduction

One of the main elements of curriculum design is the student workload (Kember, 2004). In fact, across the European Higher Education Area (EHEA), a description of qualifications is recommended in terms of the student workload (EC, 2005a), among other aspects. Student workload can be interpreted (Kember, 2004) as the number of working hours, which could consist of attending lectures, seminars or tutorials (contact hours) plus independent and private study, preparation of projects, examinations, and so forth (EC, 2005b).

Each course, and by extension, each degree, usually has a certain number of credits, which implies student workload. In different countries a credit is associated with a different workload. In the EHEA, it is suggested that 1 credit (the European Credit Transfer System, ECTS) represents around 25–30 student working hours (EC, 2005b). Each academic year has 60 ECTS. In the US educational system, the amount of academic work is also measured in credit hours (USDED, 2010). In this case, credit hours are the number of hours of instruction scheduled per week. A normal full-time registration in a bachelor’s degree program usually entails a total of 120 credit hours, which represents at least 5400 h of dedicated academic work. This implies around 45 h per credit. In countries and institutions participating in the University Mobility in Asia and the Pacific Organization (Universities Australia, 2010), a full-time subject load varies. According to the University Mobility in Asia and the Pacific Credit Transfer Scheme, an academic year represents 60 credit points, but for example, at the University of Sydney a full-time Australian student is expected to complete 48 credit points each year which is equivalent to approximately 32 credit hours at a US University or 60 European (ECTS) credits (University of Sydney, 2010). Although the student workload is roughly equivalent to European countries (about 1500 h), a Canadian student is awarded 30 credits (Daugharty, 2002), meaning that a Canadian Credit implies around 50 student working hours.

Since credits are so variable across the different systems, student workload seems to be the bargaining chip. Therefore, finding out the actual time students spend on each course and, by extension, on the whole university degree becomes essential in an international education context.

The workload offers information on whether student efforts fit the time assigned to the course and may be subsequently readjusted.
This is important from a didactic point of view because an excessive workload interferes with adequate application of concepts and does not constitute ‘good learning’ (Chambers, 1994), promoting surface-learning approaches (Bachman & Bachman, 2006; Lizzio, Wilson, & Simons, 2002; Ryan, Irwin, Bannon, Mulholand, & Baird, 2004). Overload is also related to absenteeism from lectures (Cerrito & Levi, 1999), lack of success (Azer, 2009), lack of self-esteem and confidence (Chambers, 1992, 1994), anxiety and depression (Bachman & Bachman, 2006; Dammeyer & Nunez, 1999; Diaz, Glass, Arnkoff, & Tanofsky-Kraff, 2001) that may lead to learning difficulties (Miller, 1970, in Bachman & Bachman, 2006). In spite of this, work overload is usually a frequent element in subjects for which dedication time has not been measured (Chambers, 1992; Garg, Tuimalezaúliffin, & Sharma, 1998; Garg, Vijayshre, & Panda, 1992).

Numerous studies (Chambers, 1994; Kember, Ng, Tse, Wong, & Pompfret, 1996; Marton, Hounsell & Entwistle, 1984; Morgan, Taylor, & Gibbs, 1982; Zuriff, 2003) point out that not all learners are the same and need different amounts of time for the same learning objectives. Finding an average student is certainly very difficult. But, in order to be operative, as Chambers notes (1994): ‘we do have to take the average learner as our yardstick rather than the extremely fast or slow learner’ (p. 105).

Also, it must be taken into account that there are many factors affecting the workload of individual students: planned programmes, teaching methods, student capability and pedagogical resources (González & Wagenaar, 2003), student perception of their learning tasks and workload (Bachman & Bachman, 2006; Kember, 2004; Kember & Leung, 2006; Lockwood, 1992), reading and study skills (Lawless, 2000), motivation, personal situation and previous knowledge (Chambers, 1994), difficulty, type of assessment, contents, teacher—student and student—student relationships (Kember, 2004). In fact, some research (Kember, 2004; Kember & Leung, 2006) determines that long hours of student work are not perceived as excessive workload when the course is well designed.

1.1. Assessing student workload

Different ways of assessing student workload can be found in the literature, such as the following:

The majority of authors survey students on their opinion of workload, either using a Likert scale from very heavy to very light (Bachman & Bachman, 2006; Breton, 1999; Field, 1992 in: Chambers, 1994; Spronken-Smith, 2005; Winer, Berthiaume, & Arcuri, 2004), from a stress point of view (Cope & Staehr, 2005; Reisslein, Tylavsky, Matar, Seeling, & Reisslein, 2007), or using open questions (Kingsland, 1996; Lizzio et al., 2002; Reisslein et al., 2007; Solomon & Finch, 1998). This method is useful if the objective is to observe student perception of workload, but it does not specify the number of hours the student spent working. Students may also be influenced by their perception of subject matter difficulty, their interest in the subject (Garg et al., 1992) or factors such as content, type of assessment, teacher—student and student—student relationships (Kember, 2004). The same authors use a mixed survey, with perceptions and number of hours, but conclude that there is a weak relationship between workload perception and hours of work (Kember, 2004; Kember & Leung, 2006).

Frequently, we find student course-evaluation forms in other studies (i.e.: Greenwald & Gillmore, 1997; Lawless, 2000; Zuriff, 2003), which are given to students at the end of the course. They are asked to estimate the average time spent working per week (i.e. University of Washington forms available at: http://www.washington.edu/oae/services/course_eval/forms/index.html). The problem with this system is that it is difficult for the student to remember and accurately report the average hours dedicated to study starting from the beginning of the course or semester (Chambers, 1992). As mentioned above, students may also be influenced by their perception of subject matter difficulty or their interest in the subject (Garg et al., 1992). Nevertheless, other research (e.g. Van der Hurk, Wolfhagen, Dolmans, & Van de Vleuten, 1998) has shown that such estimation by students is reasonably valid.

In order to partly avoid this inconvenience, Schuman, Walsh, Olson, and Etheridge (1985) carried out a mid-semester survey asking the students if they studied the day before and whether that is representative of the week. The problem, according to the authors, is that ‘the students may not know much how much study, and there may also be some bias in willingness to report honestly’ (p. 961).

It is a bit more ambitious to ask each student to keep a record of all the hours dedicated to university activities (Cerrito & Levi, 1999; Kember, 2004; Kember et al., 1996; LaPalio, 1981; Ruiz-Gallardo, Valdés, & Castaño, 2006; Zuriff, 2003). The first three studies asked students to register data for a whole week. But, as Zuriff (2003) points out, the problem is that the time spent on the different activities varies substantially during the course or semester, and is strongly influenced by exam periods and essay deadlines. That is why the author avoids this problem by analysing the workload of a whole semester. However, Garg et al. (1992) states that this method is not adequate since students could be under pressure and could indicate what they think the professor expects of them.

Finally, Chambers (1992, 1994) proposes a method based on an estimate of the time students dedicate to different tasks: simple, normal or complex reading, problem-solving, etc. This is a calculation worked out before the course presentation. Teachers apply it to the course and modify the contents according to the results before students study it.

Among the advantages is a lack of student subjectivity in their answers, the different perceptions of students due to motivation or their interest in maximizing certain parts. It is not necessary to analyse a large number of results and it is useful to plan before the beginning of the course and also to check whether any of the subjects is over/under-loaded and find out where to lengthen or shorten contents, etc. Among the disadvantages is, as the author recognizes, that applying a rule is not very accurate. Setting the time for tasks such as laboratory practice or problem-solving is tricky (Garg et al., 1992; Lawless, 2000), although this could be resolved by exploratory work with a small and representative group from the total number of students.

1.2. Teaching and learning methods

Lectures comprise the standard instruction method at the Higher Education level (Biggs, 2005), especially when the Teacher/Student ratio is high. For instance, a study developed in Spain on 330 lecturers from 67 Departments showed that 60% of professors always or almost always use lectures (Baena et al., 2004). Lecture has received criticism (Azer, 2009): there are few opportunities to reflect on learning, it does not foster professional or critical skills, it is not motivating and it does not ensure the application of learning in practice. There has been a relatively recent tendency to move into more active student participation in the learning process (Breton, 1999; Peterson, 1997; Vardi & Ciccarelli, 2008). The idea that students have to be responsible for their own learning construction is becoming more accepted everyday (Breton, 1999). In fact, the European Community guidelines on Higher Education (EC, 2001) encourage lecturers to introduce instruction styles where they reduce their leading role and become a learning guide rather than a knowledge instructor. In the same line, for instance,
the Australian Commonwealth Department of Education, Science and Training (2002) highlights the importance of graduates to demonstrate professional skills, which can not be acquired by traditional memorization or understanding of what is taught. Student acquisition of generic, interdisciplinary, field-specific and subject-specific skills is becoming especially important (EC, 2005a) to better prepare them for the working world (Vardi & Ciccarelli, 2008).

The reasons that lead authors to change teaching methods can be summarized as:

- The lecturer was dissatisfied with the traditional lecture teaching because of: 1) the low number of students that pass the subject every year, 2) the high rate of absenteeism, which is progressively higher during the semester and 3) the high number of drop-outs (students who do not attend the exam).
- To be positioned more in accordance with the European Higher Education guidelines that suggest moving learning systems to more student-centred teaching methods.
- Student acquisition of high quality learning outcomes wherein specific and general skills are developed should be a challenge for a lecturer in Higher Education. This is difficult with the traditional lecture approach.

The University of Castilla-La Mancha has been proposing a number of different training workshops to educate lecturers on student-centred methods in order to foster a progressive, but voluntary introduction of these methods. The authors of this study took some of them in order to decide which was the most interesting technique for each subject. Thus, before the experience we participated in one 8 h active workshop on cooperative learning, organized by the Polytechnic University of Catalonia, Spain (UPC) and in a 5 h workshop on Problem Based Learning (PBL), organized by the University of Aalborg (Denmark). After the pilot study, lecturers visited some UPC centres which were experienced with these active methods in order to learn, not only academically, but also by observing real-life situations and speaking with colleagues.

PBL can be defined as (Hmelo-Silver, 2004) ‘an instructional method in which students learn through facilitated problem solving’ (p. 235). Here, students learn by solving problems and reflecting on their experiences (Barrows & Tamblyn, 1980). These problems are presented to the student as difficult (Spronk-Smithe, 2005; Vardi & Ciccarelli, 2008). Students have to plan and learn by themselves, which is necessary to solve the problem (Albanese & Mitchell, 1993; Hmelo-Silver, 2004; Solomon and Finch, 1998). Thus, they learn both content and thinking strategies (Hmelo-Silver, 2004) and the role of the teacher is a guide in this process.

With PBL, students are fostering a higher level of skills (Biggs, 2005). Robbins and Merideth (1994, extracted from Greening, 1998), summarize the advantages of PBL: “an increased retention of information; the development of an integrated (rather than discipline-bound) knowledge base; an encouragement towards lifelong learning; a greater exposure to clinical experience and at an earlier stage in the curriculum; an increased student–staff liaison; and, an increase in overall motivation.” (p. 2). Some studies coincide in that PBL brings better academic results than traditional systems (e.g. Anderson, Mitchel, & Osgood, 2004; Breton, 1999; Vardi & Ciccarelli, 2008) and also lead student to feel better and more satisfied (Jones & Johnstone, 2006; Kingsland, 1996; Reisslein et al., 2007; Sprokken-Smith, 2005). However, other authors found no statistical differences or lower scores (Allen, Crosby, McAlpine, Hoffman, & Munroe, 2006; Jones & Johnstone, 2006; Lieux, 1996; Phelan, Jackson, & Berner, 1994). Nevertheless, almost all research, including that mentioned, coincides in the improvement of skills and professional performance.

In PBL, students work in collaborative groups (Hmelo-Silver, 2004; Holen, 2000), which does not always imply a cooperative learning approach. Cooperative learning has some special characteristics, like the use of roles, the composition of groups, the organization and distribution of tasks, the degree of self and peer control and the requirements.

Cooperative learning has numerous advantages, such as (summarizing from Cuseo, 1996), the student gets more involved in the learning process, there is higher interaction with group partners, lower levels of drop-out, higher student responsibility, more individual learning and critical thinking, improved oral and written communication capability and greater level of student satisfaction. It also fosters socialization and the capability of working in groups and making, sharing and discussing decisions. Some of these coincide with PBL. Nevertheless, it is also convenient to emphasize that these positive aspects could be modified by some variables of individual personality such as anxiety, peer orientation, shyness, introversion and persistence, as mentioned in some studies (Kagan, 1994; Webb & Palinscar, 1996; Hancock, 2004).

Finally, the change from traditional lecture to a more student-centred approach such as PBL or cooperative learning has an impact on the system. For example, the change is uncomfortable for students at the beginning because they are only used to succeed in a new method with completely different rules (Winer et al., 2004). Peterson (1997) determined that when there is a lack of interpersonal skills in students, PBL outcomes can be compromised, and therefore those skills should be introduced into the curriculum. Solomon and Finch (1998) reported some stressors in health science students, such as uncertainty of the breadth and depth of the knowledge required, group panic, research stress, group learning stressors or lack of confidence. Finally, the majority of studies determine an increase in the perceived student workload (Breton, 1999; Kingsland, 1996; Lovie-Kitchin, 1991; Reisslein et al., 2007; Spronken-Smith, 2005; Vardi & Ciccarelli, 2008; Winer et al., 2004). This is due to extra required skills (Greening, 1998) such as self-directed learning, group working, draft or computing skills (Greening, 1998; Vardi & Ciccarelli, 2008).

Concerning the impact on teachers, many studies (such as: Kingsland, 1996; Winer et al., 2004 or Allen et al., 2006) coincide in an important increase in workload, which has been found to be correlated to teacher stress (Lackritz, 2004; Smith & Bourke, 1992; Van Dick & Wagner, 2001), and some kind of anxiety (Spronken-Smith, 2005) due to the lecturer not knowing about group dynamics or how and when to intervene.

Nevertheless, as Vardi and Ciccarelli (2008) conclude, most of these problems can be avoided by bearing them in mind and taking some measures, although constant monitoring is required in order to foresee alterations in workload. In addition, flexibility is necessary to fit them in throughout the semester (Alavi, 2002; Kingsland, 1996).

An important element to take into account is curriculum content reduction: Entwistle (1998) indicates that a large time investment is required to reach deep learning. Overloaded curricula leave students insufficient time to work, think and use information in different environments, so they will not understand everything properly (Gardner, 1993). Case and Gunstone (2002) and Case, Lewis, Fraser, and Jawitz (1999), use the phrase “cover less, uncover more” for a deeper approach with students. Cope and Staehr (2005) observed deeper learning after content selection and reduction. Ramsden (1988) points out that student studying orientation (deep vs. superficial) depends, among other aspects, on the curriculum. The fact is that the curriculum is the only part of the learning environment under lecturer control (Cope & Staehr, 2005). Also, excessive curriculum contents may produce cognitive overloading (Feldon, 2007), which can affect learning and performance.
For Biggs (2005), the curriculum is like a rectangle with a constant area, of contents × deep learning; with more content comes less deep knowledge, or more depth is reached by less content.

Further, it does not imply a mere reduction, but also an adaptation to enhance the development of future, required, work-based skills (Candy & Crebert, 1991; Lizzio et al., 2002). Thus, the syllabus design should follow a principle of balancing the breadth and depth of contents in order to maintain adequate workload and promote generic skills (Lizzio et al., 2002). Therefore, it is important to identify educationally critical aspects (Cope & Staehr, 2005; Linder & Marshall, 2003; Paakkari, Tynjala, & Kannas, 2010) as those essential to students to properly reach the proposed outcomes.

Greening’s (1998) contribution on this point is also significant. He states that the change from PBL to more content-centred teaching systems requires a slower start-up in terms of contents. This is due to the development of required skills in the student. The author also adds that this reduction should be in first year courses, where PBL should also be more structured and the student more closely guided.

1.3. Objectives

The main goal of this study is to broaden the knowledge on how much time university students spend on learning. In this case the assessment will be made after the introduction of a new type of unfamiliar teaching and learning method, which is PBL in a cooperative learning environment, while evaluating possible relationships with student performance. It is presented from a point of view different from that commonly found in the literature (student perception of their workload on a Likert scale). Here, students report how many hours they spend daily during the whole semester. More specifically, the goals of this study are:

a) To find out student workload after a teaching system change from lecture to PBL and cooperative learning, is it suitable to move from conventional lectures to more participative teaching with the same course contents or are we overloading students?

b) To examine the change in student workload over the semester. How is their time distributed throughout the semester? Is this time equally allocated in lectures and PBL?

c) To determine the effects of the change from lecture to PBL in the course outcomes. Since there is controversy due to different conclusions in the literature, it is interesting to know the behaviour of the student marks and drop-out rates.

2. Method

During the 2004–05 academic year, a pilot study was developed to find out the student workload after changing the teaching style from lecture to PBL and cooperative learning. We assessed the need for modifications in the instructional method, and in 2005–06 a new study was carried out by applying a number of substantial modifications.

2.1. Participants

This study has been developed in a Teacher Education College at a public University in southeastern Spain. Students were undergraduates from the 2nd year of a 3-year degree for Preschool Teachers. Most of them are full-time students (more than 50%). Participant ages ranged from 19 to 27 years old. The modal age was 20. During the 2004–05 academic year, 174 students (9 men and 165 women) of the 211 enrolled (82.5%) in the course took part in the pilot study. During 2005–06 114 students (5 men and 109 women) of the 128 enrolled participated in the study (89.1%).

Most students who did not participate were those who were working and were not able to follow the course or those that disliked the cooperative learning system.

2.2. The course

This experience was applied on a compulsory course in Natural Sciences, in the 2nd year of the degree program. The course has 4.5 credits divided into three Sections: Geology, Biology and Science Teaching, with 1.5 credits each, 1 h a week per section. Translated to ECTS, they are 1.4 credits, which is a maximum of 42 working hours per student, semester and section. The semester duration was 16 weeks, but the last 3 weeks were devoted to exams and there were no contact classes. The new teaching style was applied over the Geology Section. Biology was used as the control workload lecture.

2.3. Instruction method

For Biology, lecture was the dominant method. In class, the lecturer explained all contents in addition to solving some of the problems and possible doubts of the students. The final exam included short and long questions, diagrams, multiple answer questions and simple problem resolution.

For Geology, a major change was introduced. Lecture with a final exam was replaced by a PBL system with cooperative work. No concepts were explained and students were responsible for searching for information on the units proposed, and on its breadth and depth. Previous student knowledge on Geology is almost null since most students come from secondary school training in Humanities or Social Sciences, where their exposure to Geology is minimum.

The Geology curriculum was divided into 4 work packages concerning the origin of the Universe, the Solar System and Earth, the structure of Earth and the origin and evolution of life, keeping the same curriculum and conceptual objectives as previous courses taught by lecture. The core of the PBL activities consists of the design of a question (the problem) in which one or more learning objectives are implicitly included. The problem answer must be given in a short-length manuscript by following a number of instructions. Students can download a document where all the specifications in relation to the problem are given from university intranet. In addition, students find the marking criteria in the same document in order to facilitate self and peer-evaluation.

Twelve contact hours were devoted to explain different aspects of the problems, to show some example problems, student doubt resolution, and peer assessment. The main problems for students were focused on a lack of skills in solving problems.

The PBL was new to students, so it required completely different work for them. Therefore, to guide students (Spronken-Smith, 2005; Vardi & Ciccarelli, 2008), extra lessons were organized: a) on cooperative learning, b) on performing scientific studies and c) on information searching, analysis and selection (libraries and internet).

As suggested by Rué (1994), students were divided into groups of three people. From the initial 58 groups, 57 finished the subject (98.3%) during 2004–05, and 34 from the initial 38 finished during 2005–06 (92.1%). The groups had to remain the same all semester. The grading on this part of the subject was characterized by the lack of a final exam. For correct completion of each assignment professors awarded a passing mark. Assignment evaluation was carried out by: a) group self-assessment, b) group peer-evaluation and c) lecturer revision. The revised assignment was given back in a timely manner, and included comments, strengths, weaknesses and
suggestions for improvement (Higgins, Hartley, & Skelton, 2002). Students had the chance to hand-in revisions.

2.4. Data collection

To achieve our goals, students were asked to voluntarily participate in the study. As in Solomon and Finch (1998), students which submitted all questionnaires were rewarded with bonus points. Following studies such as Cerrito and Levi (1999); Kember (2004); Kember et al. (1996), we provided students with surveys where they reported their daily work. But, as indicated by Zuriff (2003), students were required to keep this diary for the whole semester.

In the second study (2005–06), students were required to fill out the same survey, but with a new row where they had to specify the daily time devoted to biology.

Surveys were collected throughout the course, and processed at the end of the experience in the pilot study, and upon their completion during 2005–06 study. Geology lasted until week 13, when students handed in the last assignment. Biology lasted until week 16, when the exam took place.

There are several reasons to choose this way of collecting data: firstly, by writing down the daily number of work hours, students may be conscious of their own work measured in terms of time, think about it and then act accordingly. Secondly, it is an approach to avoid student subjectivity as much as possible. Thirdly, this is a way of knowing if section workload is below the established maximum, and not only if students perceive whether it is high or low. Finally, it is useful because the number of student working hours is the bargaining chip across different countries, and must be known. None of the students reported any concern about the tediousness of daily evaluation. They expressed that it was fine to do it in a couple of minutes when they finished the workday.

3. Results and discussion

According to the outlined objectives, the following results can be described:

3.1. Student workload after a teaching system change from lecture to PBL and cooperative learning

During the 12 weeks that students had Geology in the pilot study (2004–05), 2056 surveys were collected. The average student worked a total of 111.92 h. Bearing in mind the 42 h assigned as a maximum, this means that the average student worked 2.6 times more than the established maximum to accomplish satisfactory academic objectives and address all contents.

These results clearly show that the preparation of this pilot study was badly planned. Nevertheless, this finding corroborates the overload determined by other studies, such as Kingsland (1996) for architecture students, Solomon and Finch (1998) in physiotherapy, Winer et al. (2004) in a law school or Reisslein et al. (2007) in science/engineering, following similar changes. Nevertheless, it provided us with important information and after reading about similar experiences: a) syllabus contents are excessive (we kept the same contents as in lecture); b) activity organization was not appropriate, excessive in number and too ample; c) the materials and bibliography were poorly selected.

There are most likely other factors, such as the lack of certain skills (to look for and to select information, group conflicts, time organization, etc.) as addressed by researchers such as a study by Lawless (2000) on students enrolled in different Mathematic courses, Winer et al. (2004) in Law or Spronken-Smith (2005) in Geography.

Some modifications were been taken into account in the 2005–06 experience due to the learning experience from the pilot study: a) syllabus content selection, following Case and Gunstone (2002) and Lizzio et al. (2002), by identifying critical learning aspects, and also learning tasks (Cope & Staehr, 2005) to extract key elements for student understanding; b) a reduction in the number of assignments and less information requested, especially for the first and second tasks, in order to progressively accommodate the skill level (Greening, 1998); c) the material and bibliography were selected in order to save on time spent searching and summarizing as suggested by Spronken-Smith (2005); d) students were strongly encouraged to attend organized special lessons on skill development (Spronken-Smith, 2005; Vardi & Ciccarelli, 2008). Also, information from the workload surveys collected has been used to monitor this experience weekly.

The results after analysing 1342 surveys for Geology (Fig. 1) show a reduction of up to 41.6 h (SD = 1.64), which is within the maximum time assigned to the Geology section (42 h). These results coincide with other studies where, after implementing some strategies and constantly monitoring workload, student work time is kept within their subject limits (Cope & Staehr, 2005; Kingsland, 1996; Spronken-Smith, 2005; Vardi & Ciccarelli, 2008). Nevertheless, it must be noted that this time is still higher than the control in Biology, after analysing 1798 surveys; 33.86 h; SD = 4.19, perhaps due to the skills that need to be applied.

3.2. Student workload temporal variation

A second interesting result is obtained by analysing Fig. 1. We can see that, in the case of Geology, the average study time per week over a semester varies noticeably depending on the week, especially in the pilot study (2004–05): 2.38 during week 2 vs. 12.97 h during week 4 (SD = 3.11). This supports Zuriff’s (2003) view when he indicates that methods to obtain student workload using only one-week surveys are defective since student effort varies substantially during the semester.

As can be observed in the Fig. 1, and coinciding with Zuriff’s (2003) results, there is a general, progressive weekly increase until a maximum is reached, and then the time goes down to a minimum and starts again. The maximum usually coincides with handing in an assignment (or an exam). It is when students make the maximum effort. The minimum usually coincides with the time when they are given the new assignment. Thus, Fig. 1 shows a clear saw shape for both Geology cases. Note the high number of hours

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**Fig. 1.** Distribution in a semester of the time the average student spends a week on a subject. The geology pilot (2004–05) and 2005–06 studies correspond to PBL with cooperative learning experiences. The biology 2005–06 study is the control study, using the lecture system. The weeks students hand in assignments are marked with arrows.
during week 2 (2005–06), which is actually the first week for this subject (since contact day is on Monday, and the semester started on a different day), because students attended skills lessons (held in extra time), organizing groups, etc.

Geology and Biology graphs along the semester are substantially different: the time devoted to Biology was low during the lecture period and increased spectacularly coinciding with examination week. Therefore, until week 13, the average student spent only 12 h (even less than the contact hours = 13 h), and the workload was very homogeneous (SD = 0.5), with a clear downward trend (y = −0.1051x + 3.7398). However, during the last week (assessment week) students spent more time (17.63 h) than they did during the whole previous period.

It is also striking that, in some weeks, the time devoted to Biology is very low, for instance, in weeks 10 and 13 (0.06 and 0.22 h). Week 10 was a holiday and week 13 was the last week before the exam period, when students are more worried about studying for the forthcoming exams than attending class. This does not happen in the PBL method.

Nevertheless, the Biology graph would be more similar to that for Geology, as more exams along the semester would be given, and come to confirm how the evaluation modifies the behaviour of the students (Biggs, 2005).

In Geology (Fig. 1), there was a slight but progressive decline in the time students spent on assignment hand-in week, which was especially clear in the second study (2004–05: y = −0.3108x + 13.013; 2005–06: y = −0.6393x + 5.4318). The reason could be (Greening, 1998; Reisslein et al., 2007; Spronken-Smith, 2005) that students progressively acquire skills and increase their abilities. Therefore, their new background may be used to interpret new information (Pajares, 1996). The increase in the last week (2004–05) contrasted with this hypothesis, but may be because students had less time to finish their assignments (2 instead of 3 or 4 weeks), and therefore efforts are concentrated.

Finally, regarding the results, is it accurate to study workload at the end of the course? Or will students be influenced by the perception of this high final effort? Coinciding with Chambers (1992) and Garg et al. (1992), only one final measure could be an important bias of reality. On the other hand, is workload at midsemester representative of the whole semester, without considering the final effort? Judging from the results, and especially in the lecture system with only one final exam, it is difficult to believe this to be the case. One solution could be two surveys, at mid-semester, which would be an average of the contact time period, and in the last week, to consider final effort before the exam.

3.3. Effects of the change in teaching and learning on student outcomes

Fig. 2 illustrates the results of student marks, on a 0–10 point scale during the academic years 2003–04 (lecture) and 2004–06 (PBL and cooperative learning) in the Geology section. Student marks follow a relatively normal distribution.

The first thing that stands out is the proportion of students that do not get a passing mark (<5 points) during traditional lecture. In both PBL experiences, this number is notably lower, with a further increase in the second PBL experience. Several explanations may be given:

a) During the pilot experience (2004–05), a high number of students were retaking the subject. For them, the new system changed perspectives and motivation (Biggs, 2005). Most of these students were disconnected (more motivated for new subjects) and did not come to lectures. The majority of them participated and passed with PBL.

b) As some authors found (Biggs, 2005; Kvam, 2000), participative methods increase retention of average or below average students, and PBL (Allen et al., 2006) helps lower-performing students. Thus, a number of those that are slightly under the border are favoured. But other researchers (Allen et al., 2006; Breton, 1999 or Phelan et al., 1994) found no statistical differences between grades in PBL and in lecture.

c) Group work is a way of keeping in touch with the subject for those that are retaking it. With PBL and cooperative learning, they feel obligated to work on it and to be part of the group (Cuseo, 1996). These students participate throughout the whole semester and do not study only the last week, when it is difficult to understand all the concepts required.

The increase in the number of failed students during the second experience could be because students who re-took the subject (after taking it first in the lecture system) had already passed. And those that did not pass in the pilot study were perhaps not comfortable with PBL. If this was the case, the system was beginning to reach equilibrium.

Finally, there is a high probability that the average mark was higher with PBL than with lecture (p < 0.005), as shown by unilateral contrast for independent sample comparison. Fig. 2 shows that most passing students were within a range of 7–8.9 points in 2004–05 and 6–7.9 points in 2005–06, vs. the 5–5.9 points in the lecture system. This may be related to the fact that the knowledge was developed by the students themselves and was therefore better assimilated (Biggs, 2005). Results agree with other research that found higher scores in PBL than in lecture (Anderson et al., 2004; Breton, 1999; Vardi & Ciccarelli, 2008), but disagree with studies such as Jones and Johnstone (2006) who found lower scores with PBL groups. Similarly, Allen et al. (2006), Jones and Johnstone (2006), Lieux and Phelan et al. (1994) found no statistical differences in overall grades. In our case, the average mark among students who passed the subject was 6.1 points in lecture, while it increased to almost 7.8 and to 6.8 points in respective PBL studies.

This result also shows that student marks were lower in the second PBL experience compared to the pilot study, which was after applying strategies such as an important reduction in contents. The explanation is not simplistic, since many elements are implicated. The most direct justification is that there is more learning and better results when more time is spent on the subject if students do not perceive it as a higher workload. Even though most research concludes that workload is related with the surface learning
approach and lower scores, studies such as Kember (2004) or Kember and Leung (2006) state that it is possible to have a high number of study hours directed towards high quality learning outcomes if there is a good learning environment. Some keys are motivation, the student—lecturer relationship, student engagement, coherence in the program, concentration on syllabus key elements, assessment of understanding, a good class environment and teacher support (Kember, 2004). Even if not all of these aspects were implemented, results indicate that students feel comfortable and motivated. Perhaps they have perceived this Geology Section as a challenge, as something new and interesting to do. But, certainly, the excessive time and efforts took time away from other subjects and probably from their leisure time as well.

If we had questions about student perception of workload, and following results of the same authors, students would not have reported workload levels to be much higher on a Likert scale, as they seem to be in a “good” learning environment.

During the second PBL experience, although more of those key elements were in the system (such as content reduction or concentration on key elements), the reduction in student working hours led to balancing results to a more selective system, with a higher number of failed students. However, as mentioned before, the higher number of students retaining the subject in the first PBL experience might have distorted results.

Finally, the number of drop-outs, or students who did not take the exam (coded as NP), is far lower in PBL. This success may be related to cooperative learning, which produces higher motivation levels and responsibility (Cuseo, 1996), and the student is involved in the system throughout the whole semester. The low drop-out level is also remarkable, even with such a high workload. This disagrees with some research that relates high workload with high levels of drop-outs (Woodley & Parlett, 1983). Reasons could be, as mentioned before, motivation and a perception of a good learning environment. Nevertheless, it can be highlighted that in the second PBL experience this drop-out level is still lower, as is workload.

4. Conclusions

While there are many studies that evaluate student perception of workload from different perspectives, the literature is very limited on the evaluation of the true number of hours students worked. Perception offers information on many elements of the Teaching and Learning process, but does not report the number of hours the student spends on the subject. Indeed, they can be poorly related. However, courses and, by extension degrees, are awarded according to a certain number of credits, which translate to a specific number of hours that students spend on all academic tasks. Therefore, it is necessary to know how much time the average student is actually spending on our subject.

It is also important to know student workload in terms of ethics. We may certainly be underloading students, and then we are made aware that our subject poorly defines goals, activities or contents. This would mean that students are paying for an education that we are not giving them and the university is recognizing something that does not fit reality. Or perhaps professors are overloading the course: then the student must take time away from other subjects or from leisure time.

Further, this work is important from a point of view of recognition across international Higher Education jurisdictions, which is in terms of credits. These credits mean a different number of work hours depending on jurisdiction. To standardize them, the workload must be known in terms of time allocated by the average student on each course, and by extension, on each degree. Working hours are, thereby, the actual bargaining chip across international educational systems.

The method proposed has demonstrated that is suitable to find out the time students spend on a subject, not only in terms of overall effort, but also how it is distributed throughout the course. From the analysis of the average weekly workload, the following weeks can be planned, so work is readjusted and compensates for any over- or under-load in terms of hours. At the same time, in subsequent surveys we can check, whether the measures taken have been effective.

The literature contains few studies that evaluate the workload after a severe change in teaching method, towards a more student-centred one and is especially lacking in those that keep a record of the number of hours worked. The consequence, if the contents are the same, the course is deficiently planned and students are not used to the system (lacking required skills), may be lead to significant student overload, as this case study highlights. Results show that the average student took 266% more than the time assigned for the subject. After extensive planning, this workload has been brought to less than the maximum established. Thus, this result shows that the pilot project planning was badly designed, and the importance of monitoring student workload, especially during a significant change.

Four elements have been successfully determined for reducing workload: curriculum content selection, skill training, assignment reduction in terms of number and organization (increasing work and content over the semester) and selection of provided materials.

Student workload varies notably during the semester, creating a saw-shaped graph, with as many peaks as the number of assignments (or exams). Maximums appear during the assignment hand-in week, with minimums the week after, following a new increase. This behaviour contrasts with that observed for conventional lectures, where the student spends little time throughout the semester, showing a small standard deviation, in contrast with the exaggerated effort during the examination week. In fact, students spend more time during the pre-exam week than in the rest of the semester. Increasing the number of exams may cause the lecture graph to approximate the PBL graph.

For this reason, if weekly workload surveys are excessive, at least two surveys are required to define the most critical points: assignment hand-in week (or exam week) and the week after. Thus, a more accurate workload average may be extracted.

Results also show that PBL demands more time than lecture, measured weekly and as a total, probably due to the required development of necessary skills. In the PBL approach, there is a slight tendency to reduce the time spent on these maximums, perhaps due to progressive skill acquisition by students.

In this case study, PBL and cooperative learning had a clearly positive influence on student performance. The number of students who did not take the exam or failed was markedly lower than in the lecture system. Average marks were also higher, perhaps due to increased motivation, responsibility and satisfaction, but probably also because knowledge was more assimilated.

During the second PBL experience, students scored lower even though the curriculum content was reduced. The most probable justification is that although higher workload is usually correlated with lower scores, if students perceive a good learning environment it is possible to obtain a high number of study hours and quality learning outcomes. More time spent working on the subject leads to better marks.

Finally, the authors would like to point out that additional work is required on testing this process with other courses, degrees and between genders, ethnic groups, etc. Contrasting workload data with workload perceptions is also of interest since several studies found significant differences. To evaluate workload amount and distribution in PBL vs. a lecture course with some exams along the semester, is also important to better support some conclusions. It would be
interesting to contrast not only marks, but also the skills acquired by students or the type of learning (surface, strategic or deep) by comparing PBL to traditional lecture.

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