A Probabilistic Approach to Student Workload: Empirical Distributions and ECTS

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Abstract
The ECTS, European Credit Transfer System is now widely used throughout higher education institutions as it facilitates student mobility within Europe and the comparison of study programs and courses. Most European institutions provide students with the number of ECTS each course and module is worth. A full-time student needs to complete 60 ECTS per academic year, which represents about 1500 to 1800 hours of study. However, there is a lack of research showing that ECTS metrics have been properly implemented in different degrees and universities. The aim of this paper is to assess the relevance of the ECTS metric as a valid indicator of students' and courses' workloads. Detailed workload measurements have been taken in two Spanish universities, with 250,000 work hours monitored from 1,400 students. This is the first study published with such a large dataset that includes a range of simultaneous courses and throughout a whole semester. Empirical distribution functions of workload indicators have been obtained. Evidence is provided indicating that nominal ECTS credit hours may be overestimated, that the variability of student workload could be too large for ECTS to sensibly characterize course workload and that workload statistics of courses with same nominal ECTS are generally not comparable.
Although the ECTS metric conception seems to be a valid metric to facilitate mobility between different institutions and higher education systems, in practice, according to this study, it requires revision, at least in the two institutions that have been included in this study. Further studies like the present one are required to test if this is a broader problem that has implications for the comparability of degrees across Europe.

Keywords
Student workload; workload monitoring; ECTS (European Credit Transfer System); EHEA (European Higher Education Area); workload ECDF (Empirical Cumulative Distribution Function)

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Introduction

Understanding how much time students dedicate to their academic activities, how this workload is organized in time, how it affects their satisfaction with their university and how these aspects affect (or do not affect) academic success are cornerstones of university education(Higher Education Policy Institute and Higher Education Academy 2015; Karjalainen et al. 2006).

Presumably inspired by this idea, one of the key aspects in the European Higher Education Area's (EHEA) rationale has been to characterize the courses/subjects/modules by the work-hours that students need to pass them, leading to the European Credit Transfer and Accumulation System (ECTS)(Commission 1998). This metric is used across European Union university national systems to compare courses of similar topics and to convert credits to and from university systems around the world (Martínez and Moreno 2007; Van-Damme 2001).

This quantitative approach to student workload has been questioned by researchers like Kember and colleagues (Kember 2004; Kember and Leung 2006; Kember et al. 1996; Kyndt et al. 2014) due to the difference between perceived versus actual workload. Moreover, other authors have proposed the idea that a combination of quantitative and qualitative approaches is necessary to obtain reliable workload data (Rozman et al. 2014).

Apart from using quantitative measurements of workload to discuss EHEA's ECTS paradigm/framework, it is important to have such quantitative measurements in cases when overloading can become an issue: e.g. after radically changing the teaching and assessment methodology of a certain course (Ruiz-Gallardo et al. 2011) or when assessing the influence of workload on the students' rating of instructors (Greengard and Rokhlin 1987; Jackson et al. 1999; Seaton et al. 1980; Toland and De Ayala 2005; Watkins and Gerong 1992). Quantitative measurements are also important for researchers interested in developing production functions in education(Bartual-Figueras and Poblet-Farrés 2009; Jano-Salagre and Ortiz-Serrano ; Martínez and Moreno 2007; Millot and Lane 2002; Schuman et al. 1985), who investigate the factors that influence the academic performance of students, workload being one of the main ones.

The ECTS paradigm is questioned in this study not due to its quantitative nature, but due to the limitations, it may present in the way that is implemented. A probabilistic approach to workload is elaborated and such approach is used to discuss how representative the ECTS workload estimates are when compared to data obtained with the developed probabilistic framework.

Theoretical background

The ECTS metric

The American credit hour system has been used for more than 100 years for measuring the student workload, faculty workload, tuition, costs of the program, and funding(Nosair and Hamdy 2017). Although the American credit hour system includes students' activity to some extent, it is not a measure of the actual effort exerted by learners (McDaniel 2011). Alternative educational credit frameworks have been evolving as a replacement for the traditional model (Nosair and Hamdy 2017). So for example, McDaniel (McDaniel 2011) suggested reframing the existing academic credit by making the "level of students' effort" rather than the "contact hours" as the foundation of the credit system. Alternatively, Watkins and Schlosser (Watkins and Schlosser 2000; Watkins and Schlosser 2003) suggested using the Capabilities-Based Educational Equivalency units (focus on the attained knowledge and skills of learners as a standardized measure of educational achievement based on taxonomies). Among these innovative credit hour systems, within the EHEA framework, is the European Credit Transfer and Accumulation System (ECTS), which is a numerical descriptive value of qualification expressed in terms of student workload. The ECTS system sets the number of credits at 60 per academic year, with a total workload between 1500 and 1800 hours (Commission 1998). This leads to an equivalence of 25-30 hours per ECTS credit (or simply ECTS). The equivalence 1.5 ECTS = 40 hours of total work (1 ECTS = 26.67 hours) is frequently assumed by universities. Considering the importance of requiring reasonable amounts of work from our students, it is therefore interesting to investigate in which extent this equivalence (and the 25-30 hours range itself) is realistic. The last two Student Academic Surveys in the UK (Higher Education Policy Institute and Higher Education Academy 2015; Higher Education Policy Institute and Higher Education Academy 2016) highlighted the fact that workload increases as students progress, with "third- and fourth-year" students reporting the most demanding workload with a total of 33 and 36 weekly hours, respectively. Nevertheless, for many full-time students the total number of weekly hours they report spending on academic work does not equate to the standard definition of a full-time job, nor to the guidelines of the Quality Assurance Agency for Higher Education (QAA), which assume a workload of around 40 hours per week during term-time.

Considering that the ECTS equivalence paradigm is used in Europe to define courses workload, it is relevant to assess whether courses that nominally (or officially, or theoretically, the three terms being used indistinctly in this paper) share the same number of ECTS also share the same actual student workload. Currently, some universities: e.g. "Universidad de Castilla La Mancha" (UCLM) and Rey Juan Carlos in Spain, define a fixed ratio of contact versus independent work (40% vs. 60% and 33% vs. 66%, respectively) in order to assign the ECTS credits to each course. This approach is applied in similar ways in other European universities.

The particular reason for the prevalence of these ratios in Spanish universities is that the amount of teaching hours (scheduled contact hours) is the main factor for assigning academic staff resources to the departments. In consequence, students' workload and ECTS have become a central topic in the Spanish university system during recent transition years to the EHEA framework, leading to a significant number of journal and conference publications (Arana et al. 2005; Ruiz-Gallardo et al. 2011; Ruiz-Gallardo et al. 2016).

Methodology

Previous workload measurements

It is difficult to obtain reliable, large-scale and high frequency measurements (in every contact session) of independent study work performed by students since there is a range of methodological problems (Chambers 1992): (1) work definition may vary from student to student: according to Chambers (Chambers 1984) it seems that students' perception, the degree to which they feel overburdened, is affected by both the extent of their interest in a topic or task and by how difficult they find the work, and that these two variables are themselves related; (2) most students are unreliable record-keepers, this difficulty may be compounded by the fact that there are problems surrounding what students actually defined as "work"; (3) students may feel compelled to report a level of work they believe teachers would regard as respectable, and finally; (4) students reporting heavy workloads may be reflecting their own anxieties or their difficulties dealing with several sources of information rather than the amount of work itself, this has been shown in students who has suffered interruptions in their students due to illness, family difficulties or whatever. Moreover, students stated that they feel overloaded when they are under stress especially before exams (Nosair and Hamdy 2017).

However, there are several methods and experiences for determining the independent (individual or team) workload in the literature:

(1) Surveying the students by giving them questionnaires at the end of a certain course or experience (Breton 1999; Higher Education Policy Institute and Higher Education Academy 2015; Higher Education Policy Institute and Higher Education Academy 2016; Spronken-Smith 2005; Winer et al. 2004);
(2) Forms given to the students at the beginning of the season, expected to be completed on a periodic - usually weekly - basis for the duration of the course, to be handed back at the end of semester for analysis (Arana et al. 2005; Barjola-Valero et al. 2014; Darmody et al. 2008; Greenwald and Gillmore 1997; Krzin-Stepisnik et al. 2007);
(3) Selecting a sample of the student body and carrying out interviews in order to extract study-workload

averages per day (Nosair and Hamdy 2017; Schuman et al. 1985);

(4) Detailed diaries (Bartual-Figueras and Poblet-Farrés 2009; Kember et al. 1996);

(5) Periodic (short periods, i.e. daily/weekly) collection of data (Jano-Salagre and Ortiz-Serrano ; Ruiz-Gallardo et al. 2011; Ruiz-Gallardo et al. 2016; Ruiz-Gallardo et al. 2006; Zuriff 2003).

The first method could be subjective as it depends very much on the memory of the student, and similar problems may occur with the second and third methods. Diaries, usually collected at the end of semester, could be in principle more accurate, but their reliability is questionable as it is difficult to verify, post collection, that the entries of the diaries were actually updated on a daily basis. Moreover, the studies referred to under each of these methodologies are undermined by one or more of the following limitations: either a relatively small number of individual courses, or a small fraction of the entire student population, or a short duration of the study.

In fully online courses, alternative methods to assess the students' workload are being developed, capable of rendering detailed information on workload amount and distribution(Jay 2011; Lawless 2000).

From this literature review, it is apparent that detailed quantitative values of workload or variables related to workload for numerous and heterogeneous students´ populations accounting for all contact (or in-class) and independent (or out-of-class) activities are scarce. Moreover, the ones available are not designed to provide any information regarding the relationship between the contact hours and the independent, out-of-class workload. In addition, there are few measurements of how the workload is statistically distributed, mainly in individual and teamwork. In consequence, this initiative was set up in order to monitor the time dedicated to every contact and independent activity by students from two faculties in two different universities the whole semester. The work presented here is included in method type (5) by collecting information in contact sessions that take place at least bi-weekly basis. The aim is to reduce the errors arising from students inaccurately recalling the amount of work performed when reporting it since they have to report their workload in every session and reduce stress influence making this reporting a routine. Moreover, this study has the advantage of including simultaneous courses, of a large population of students and throughout the whole semester that allows treating workload-related variables as random variables. The authors have not found such a dataset in the literature.

On the other hand, the literature is lack of studies in the relationship between contact and non-contact hours as well as in the distribution of workload across individual and group activities, both key points of this research.

Research questions

1. Is it possible to obtain a detailed and reliable description (collecting information in every contact session) of the workload of a moderately large population of students (of the order of 500) in a set of courses?
2. Is it possible to conduct these measurements for an entire semester, so that effects that are localized in time do not bias measurements?
3. Is it possible to statistically characterize student workload by estimating cumulative distribution functions for raw and derived random variables?
4. Is it possible to challenge, from such measurements, the idea of ECTS workload equivalence and consequently the established idea of equivalent ECTS credits modules implying an equivalent or at least similar workload?

Workload definition

In this paper student workload is defined as the sum of the scheduled or time-tabled contact hours (classroom activities that can be lectures, practical classes, laboratories, etc..) and out-of-class independent study (both individual and in group, including the time spent within online learning environments). Other authors (Bachman and Bachman 2006; Darmody et al. 2008) consider simultaneous term-time employment as part of the student workload. However, for simplicity's sake, it has been limited the scope of this research has been limited to those two categories of scheduled contact hours and out-of-class independent study.

Context

The data collection has been carried out in two faculties in two Spanish public universities: the Naval Architecture Faculty (ETSIN) of the Technical University of Madrid (UPM) -based in Madrid, and the Toledo Engineering School of the Castilla la Mancha University (UCLM). The students at UPM were enrolled in a Naval Architecture degree while those in UCLM were enrolled in Industrial Electrical Engineering and Industrial Electronic Engineering degrees. Data for 750 and 650 students from UPM and UCLM respectively, for a range of modules, were collected for this study. Moreover, data were collected as well for a module in a Teaching Faculty and a module in an Architecture School at the UCLM during one semester, however the data from this population were not included since we thought that these data were not representative as only include one subject per degree. Initially when this initiative was started, we thought it would be possible to obtain more data in several schools but finally it was not possible. Most of the selected modules includes in this study were first year since the criteria to select courses was the wiliness of lecturers leading modules to get involved in this study. However, statistical analysis no included in this paper but in a conference paper by the authors demonstrated that there was not bias due to this fact (Baeza-Romero et al. 2014).

UPM data were obtained in the second semester of the academic year 2011-2012, and in UCLM over two consecutive academic years (2012-2014). Since there were no significant changes, in either, the degrees or in the educational framework between these periods, adjustments were unnecessary to account for the surveys being conducted asynchronously in the two institutions. 75,000 records from students were obtained, accounting for 250,000 hours of monitored work. One record consists of three fields: the student identification number, private individual work and the private teamwork. The meanings of these fields are later discussed in the paper.

A gender statistical study of the students of both schools involved in this research showed that the two populations have less women than the average in most Spanish university degrees (typically ~%50%) (Ministerio de Educación 2015), UPM presents 25% while UCLM has 15%. In relation to the entrance mark in the considered degree both populations are different, too. Typical entry marks for UPM students was 6.9 while for UCLM students was 5. However, the fact that results from both populations are comparable (see section *Differences between UCLM and UPM*) make us to think that gender or entry marks are not important factors for the conclusions of in this study. Although they can be interesting factors to considerer in a more detailed study on workload factors.

Implementation and design aspects

The methodology applied to monitor student workload information in a series of courses in every contact session using optical reader forms followed the following steps:

1. A multiple choice optical mark reader form was designed and contracted externally.
   The form is divided in two sections (see Figure 1). The lecturer completes the upper section, and the bottom section is designed to hold records for a maximum of 30 students due to space limitations in the sheet. The lecturer's section of the form has space to indicate the course, date, duration, type of the monitored session, and the lecturer's related workload. Each form is printed with an individualized number (ID), which allows one to identify each session in the database, and link together those sheets for sessions with more than 30 attendees (through the SHEET1 ID field, referred to as the main sheet).
   In the students´ section, each student is identified with a 3-digit ID and has to write the amounts of out-of-class individual and teamwork he/she has spent since last session for this subject working individually or as part of a team. A series of options are offered to the student in order to report the workload: zero, 5 minutes, 0.5 hours, 1 hour, 2 hours, 3 hours, 5 hours, 8 hours, 12 hours, and 20 hours, which is the maximum. The students are asked to mark the option that is nearest to the real value. A discrete set of values will form the distribution of workload for single activities (either individual or group work). This approach has the advantage of simplicity and ease of use, with reasonable precision.
   "Teamwork" was paid special attention within this initiative because it is one of the generic skills most valued by employers (Abad 1998; Aneca 2004; Aneca 2005; Aneca 2006; Dunne and Rawlins 2000).
2. The initiative was presented to the Educational Innovation and deans of both institutions, and received approval and sufficient funding for the small expenses involved.
3. Lecturers interested in the initiative were recruited. One important task of the lecturers was to explain to

their students the relevance of the project in order to engage them in providing reliable information regarding their workload. The students were informed that their participation was voluntary, and that the information collected was confidential and data always were treated like that. The lecturers involved reported high to full students´ participation. The workload of the students that did not attend the contact sessions was not monitored.

4. A 3-digit ID was assigned to each student. The students were informed by email or in person of their personal ID and asked for permission to access their marks and personal information. It was clearly stated that the use of the data would be for research on student workload, use of personal information would be restricted to such objective, and that no personal information would be published nor leaked.
5. Data collection was performed. Forms were circulated in the classroom and completed by students in every contact activity by marking the boxes corresponding to their individual and team workload, corresponding only for this course, since the previous scheduled session. Lecturers also completed their section on the form.
6. Completed forms were optically read, data files generated, and a database was created.

Information was analyzed and dissemination activities were carried out, with some limited scope conference papers already published (Baeza-Romero et al. 2013; Baeza-Romero et al. 2014; Souto-Iglesias 2013) and some results of the initiative having been presented to students and lecturers at UCLM in 2014. A probabilistic analysis method was applied using the cumulative distribution function (CDF) of the considered variables. This approach is quite novel in student workload literature. A robust estimation of the CDF of a random variable provides information which allows to consistently contrast hypothesis regarding the population as well as to marginalize such pdf attending to available data, such as gender, amount of teamwork, institution, course, year of study, etc.

Statistical Analysis

The raw data can be statistically treated looking at primary variables such as the distribution of individual or teamwork, and by defining derived random variables from this primary data with the objective of illustrating the main characteristics of the students' effort. In present research, these variables are typically based on building out-of-class versus contact hours´ ratios. This kind of ratio could provide consistent information regarding student workload since both nominal ECTS and contact hours are known for every module. For instance, in UCLM the nominal ECTS ratio is 25 hours of workload per ECTS credit (150 hours = 6 ECTS module). Considering that 4 contact hours per week are assigned to these courses and that the semester lasts approximately 15 weeks, a total of 60 contact hours (15 weeks × 4 hours/week), and hence, 90 independent out-of-class hours, are theoretically assigned to that course, leading to an out-of-class/in-class workload ratio of 90/60=1.5.

Moreover, other statistical variables can be defined from raw data as below:

- From each record completed by a single student, a, comprising the individual and teamwork prior to the contact activity i where the data is taken, a straightforward random discrete variable β can be defined according to equation (1):

$$\beta_i^a = \frac{I_i^a + T_i^a}{D_i} \qquad (1)$$

where I_a^i and T_i^a are the individual work and teamwork of student a prior to the activity i, and D_i is the duration of the activity i. Although the ratio β is a discrete variable (since it is by dividing a set of finite discrete values (5 min, 0.5h, etc.)), their empirical cumulative distribution function (ECDF) has been approximated by a continuous one, obtained using a Gaussian kernel (with the MATLAB "ksdensity" function) (Kvam and Vidakovic 2007) and it is shown in Figure 2 for UCLM and UPM. The median of this distribution is 0.5 and the 80th percentile is 1.5. This implies that 80% of the records are below the official out-of-class/in-class workload ratio in UCLM. Since workload tends to accumulate in certain periods, this does not imply that the final actual ratio will be that low for most students. However, it is an indication that the ECTS official ratio does not generally hold for the course duration.

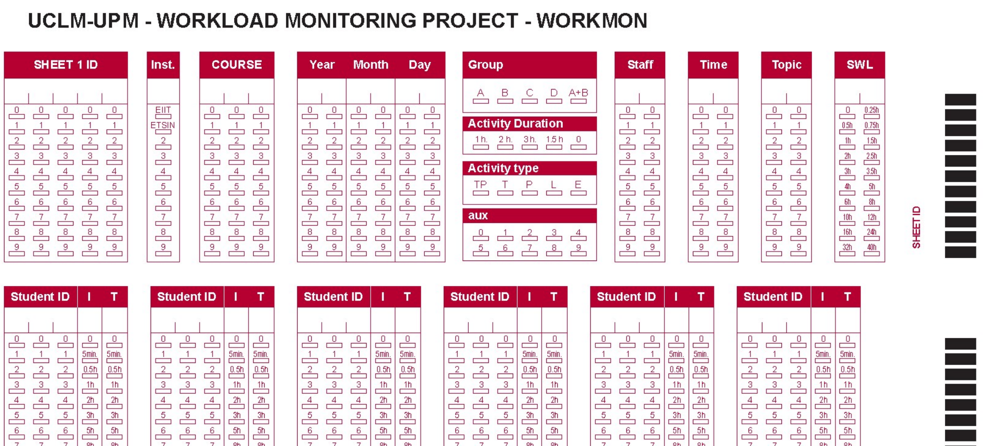


Figure 1. Data sheet

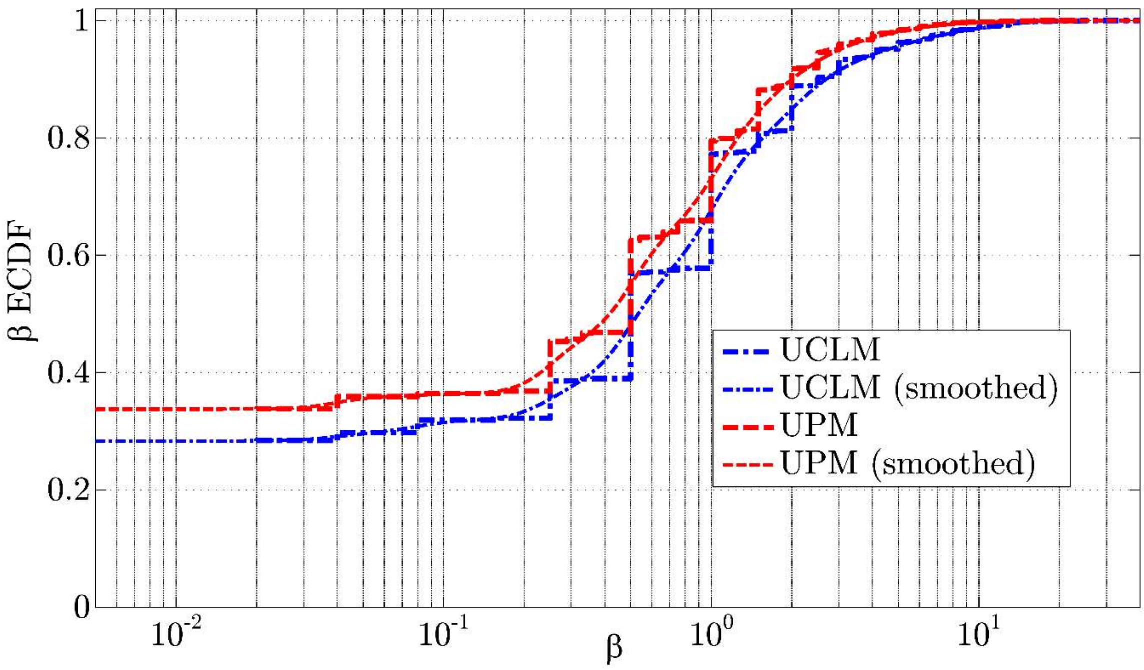


Figure 2. Empirical cumulative distribution function of β ratio for UCLM and UPM (75,000 records in total)

- Another random variable that can be defined is α_a^k that is the ratio of out-class hours that a student *a* has dedicated to a course *k* divided by the duration of the monitored contact activities:

$$\alpha_a^k = \frac{\sum_i (I_i^a + T_i^a)}{\sum_i D_i} \qquad (2)$$

where *i* is every activity that a student *a* has attended.

This variable can be compared with ECTS workload equivalence (for UPM 40 hours=1.5 ECTS, i.e. 1 ECTS = 26.7 hours work, for UCLM see before). If the α ratio for a certain student in a course is lower than the one officially corresponding to that course, this means that the ECTS target is not met. On the contrary, if α ratio for a certain student in a course is larger than its official value (and student has attended most sessions) this would mean that ECTS target has been met. Additionally, if α ratio for a certain student in a course is larger than its official value, and the student has attended a low number of sessions this would correspond to students whose attendance is low and for whom the ratios are less meaningful, and this need to be taken into account in the statistical treatment of the data.

Considering these factors, the way in which α is distributed along the population of students can be a consistent indicator of how, from a statistical point of view, the effort of the population of students correlates to the official ECTS equivalence.

- The third statistical variable considered in this study is γ^k, which is a global estimate of the out of-class versus in-class workload ratio for a course *k* for the total of students, and that is defined by equation (3):

$$\gamma^k = \frac{\sum_a \sum_i (I_i^a + T_i^a)}{\sum_a \sum_i D_i} \qquad (3)$$

Since a single value is obtained for every course, this indicator is the most convenient, among those considered, for comparing different courses with the same nominal ECTS.

- Finally, the student workload (in hours) per credit, here referred to as h_{ECTS}, is the estimation of real workload per ECTS credit. As previously discussed, this value is officially expected to be around 25-30 hours, more precisely (40/1.5=) 26.7 hours in a large fraction of universities. It can be calculated from γ according to equation (4):

$$h_{ECTS} = \frac{\gamma^k \times T_{class,k} + T_{class,k}}{C_k} \qquad (4)$$

where $T_{class,k}$ is the total number of contact hours of a course k , which can be estimated considering that each course has a duration of 15 weeks and the weekly number of contact hours for this course, and C_k is the number of ECTS credit of this course *k*.

All these variables can be studied for a certain course, how they are evolved throughout the weeks of a course, how they behave for a chosen subset of the population, etc.

Results

In this section, the distributions of primary and derived statistical variables defined previously are presented. First, primary data are shown to have a global picture of the workload distribution patterns and after derived variables are studied.

Quality of data collected

One aspect of the data quality is to assure that data has been collected in most of contact hours and for most of students during the courses included in this study. This is not an easy task especially when several lecturers are involved. In order to document in how many contact activities the data collection did actually not take place, the anticipated weekly distribution of sheets per module and per group (some modules are taught to several groups) was worked out for all modules monitored. Bank holidays and other eventualities (e.g. graduation ceremonies, a teacher missing a lesson for any personal reason, etc.) were accounted for.

As example, in Fig. 3 the distribution of anticipated main sheets versus obtained is displayed for one course with four groups, each with a different lecturer and coordinated by one of the coauthors (this is the worst-case scenario). Globally, 116 primary sheets were collected, close to the 121 primary sheets planned. The expected number of sheets can vary due to bank holidays as it is the case of weeks 8 and 11. This is just one single module, but the rest of the modules behaves better than this one. However, we need to take into account that sheets from exams are critical since there it is where more out-of-class hours are accumulated.
The decrease in the number of sheets is related to the fact that less students attend to lectures as the course goes (in both universities attendance to lectures is not compulsory) but the ones who attend still continue filling the sheet. However, monitoring continuously the ratios of out-of-class vs. contact hours allow us to correct for the lack of attendance at the end of the course, and we highlight that during the exams workload is as well recorded. Additionally it is observed that these results are consistent with the ones for the subset of population that we have called in the paper A100 (see Figure 5 and Table 1).

There was a small part of the students who decided not to get involved in this study. There is not quantitative data to determine the exact percentage but according what the lecturers reported was below a 5%.

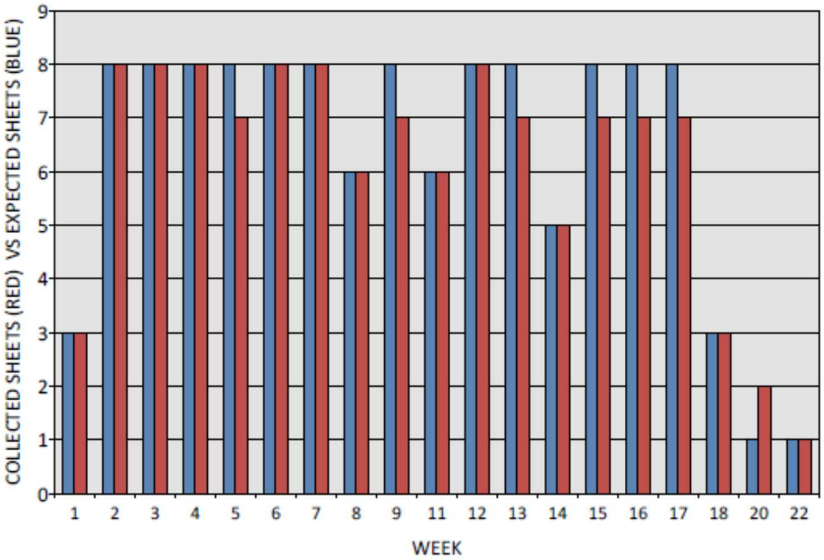
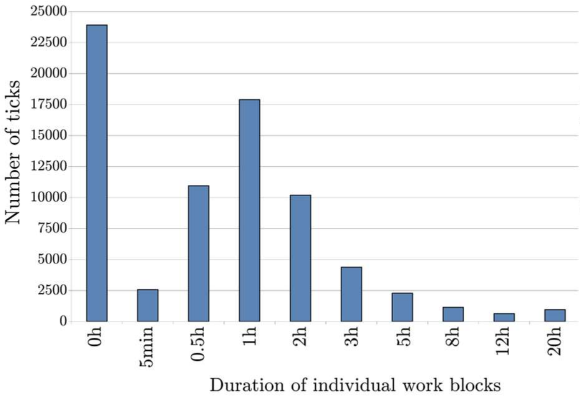


Figure 3. Collected vs expected main sheets for a single module with four different groups and 2+2 hours weekly class distribution

Individual and teamwork

In Figures 4 a) and b), histograms of all ticks for independent, out-of-class individual (I) (a) and team (T) works (b), are shown. The mode is zero in both cases but with frequencies around 30% for the individual work and 90% for the teamwork. There is a small fraction (around 4% of ticks) corresponding to 5-minute individual work blocks, given as an option for those students who take a fast look at their notes between two lessons. It is clear that individual out-of-class work dominated over teamwork.



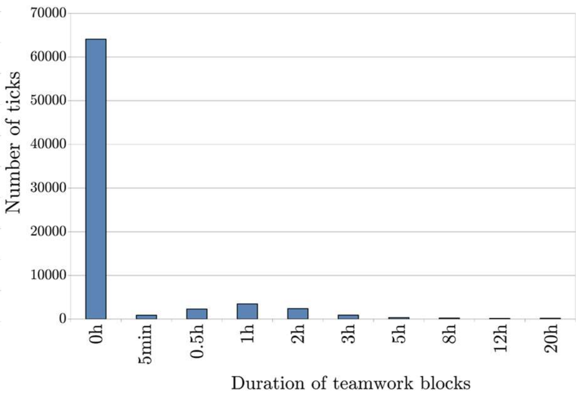


Figure 4. Blocks of out-of-class individual (left) and team (right) work histogram

Differences between UCLM and UPM

β:OUT-OF-CLASS VS. IN-CLASS SINGLE RECORD RATIO

The ECDFs of β for all records from both institutions records are presented in Figure 2. The shapes of the curves are similar, separated by a certain gap and with no intersection. Larger β values percentiles consistently correspond to UCLM. The medians are similar, 0.41 for UPM and 0.53 for UCLM, with the modes being zero in both cases, and with frequencies close to 0.3, a constant in this study. A two-sample Kolmogorov-Smirnoff test carried out at the usual significance level of 0.05 rejects the hypothesis of equal distribution. However, both distributions provide similar evidences in order to later discuss different aspects of the ECTS metric.

ECTS workload

α: SUM OF OUT-OF-CLASS DIVIDED BY SUM OF IN-CLASS WORKLOAD FOR EACH STUDENT

The α indicator can be analyzed across the individuals of a certain population of students (e.g. those in a certain course, those for whom a minimum amount of data is available, those who passed the course, those who are female, male, first year students, students taking the course for the second time, students taking the course with a certain lecturer, etc.), obtaining in such cases a conditional probability description of this random variable. In Figure 5 the α ratio ECDFs are plotted for all available students, as well as the conditional estimations for those students for whom at least 100 contact hours have been monitored (this subset of students will be referred to as A100, and it comprises 500 students, compared to 1,400 in total). The median for the whole population is 0.88 versus 1.0 for the A100 students, far from the official ECTS ratio (1.5), and it is only achieved by 15% of the A100 students.

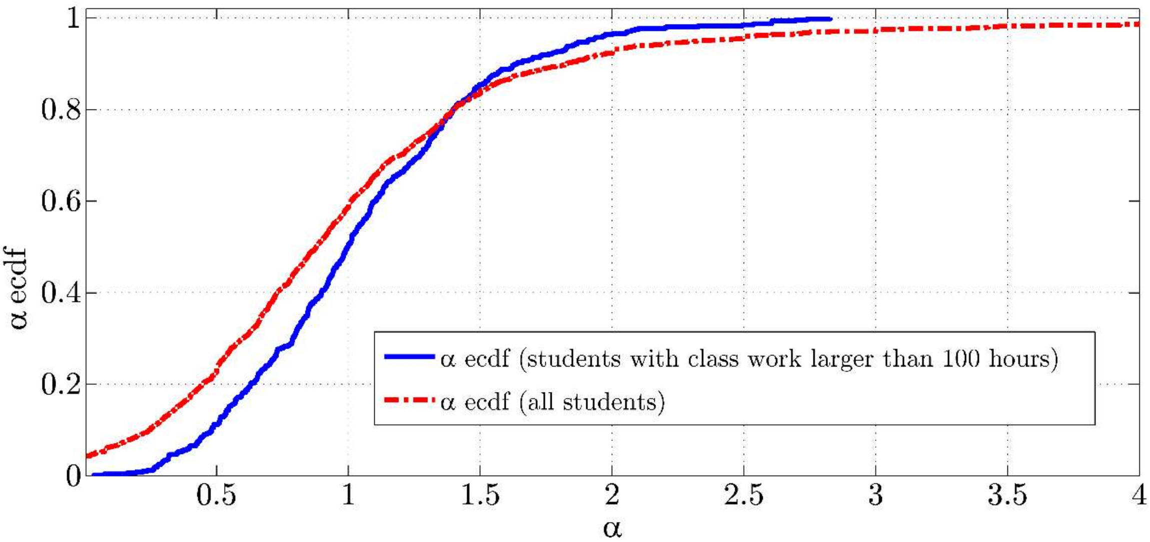


Figure 5. α ratio ECDF for all students and for the A100 subset

γ RATIO and h_{ECTS} INDICATOR FOR DIFFERENT COURSES

In Table 1 the γ ratio (global estimate of the out of-class versus in-class workload ratio for a course k for the total of students) and h_{ECTS} (the student workload (in hours) per credit) for the courses monitored within present research are summarized together with their nominal values (the values obtained according to ECTS credit equivalence). It can be seen that courses that share the same contact hours and ECTS lead to very different amount of independent study (γ values) and actual work-hours per ECTS (h_{ECTS}).

It could be argued that not all records are meaningful since some of them correspond to students that hardly attend contact sessions or that have not passed the courses. To correct for that β ratio and h_{ECTS} have been obtained for a subset that includes the population of students who have attended at least 2/3 of the lessons and who have passed the course when there was available such information (in Table 1 marked as *). It can be seen a slight increases in the γ ratio and h_{ECTS} for the selected population. However, the increase is not large and the measured h_{ECTS} ratio is still below the official value.

Table 1. γ ratio and h_{ECTS} for the course considered versus their nominal values for the whole student population and only for those students who have attended at least 2/3 of the sessions and passed the course for courses where this information was available (*). UPM are courses from University Polytechnic of Madrid and UCLM are courses from University of Castilla la Mancha

Course	Contact hours /week	ECTS credits	γ	γ*	$\gamma^{nominal}$	h_{ECTS}/ hours	h_{ECTS} */ hours	$h_{ECTS}^{nominal}$/ hours
UPM01	4	6	0.88	1.08	1.67	18.8	21	26.7
UPM02	4	6	0.94	1.19	1.67	19.4	22	26.7
UPM03	4	6	0.5	0.67	1.67	15.0	17	26.7
UPM04	3	4	0.44	0.51	1.37	16.2	17	26.7
UPM05	3	4	0.81	1.15	1.37	20.3	24	26.7
UPM06	3	4	0.76	---	1.37	19.8	---	26.7
UPM07	4	6	0.83	---	1.67	18.3	---	26.7
UPM08	4	6	0.81	---	1.67	18.1	---	26.7
UPM09	4	6	0.42	---	1.67	14.2	---	26.7
UPM10	4	6	0.74	---	1.67	17.4	---	26.7
UCLM01	4	6	0.81	0.98	1.50	18.1	20	25
UCLM02	4	6	1.19	---	1.50	21.9	---	25
UCLM03	4	6	1.11	---	1.50	21.1	---	25
UCLM04	4	6	1.17	---	1.50	21.7	---	25
UCLM05	4	6	0.93	1.14	1.50	19.3	21	25
UCLM06	4	6	1.44	---	1.50	24.4	---	25
UCLM07	4	6	0.63	---	1.50	16.3	---	25
UCLM08	4	6	1.11	---	1.50	21.1	---	25
UCLM09	4	6	1.29	---	1.50	22.9	---	25
UCLM10	4	6	0.57	0.60	1.50	15.7	16	25
UCLM11	4	6	1.39	---	1.50	23.9	---	25
UCLM12	4	6	1.28	---	1.50	22.8	---	25
UCLM13	4	6	1.08	1.18	1.50	20.8	22	25
UCLM14	4	6	1.28	---	1.50	22.8	---	25
UCLM15	4	6	0.80	---	1.50	18.0	---	25
UCLM16	4	6	0.99	---	1.50	19.9	---	25
UCLM17	4	6	0.79	---	1.50	17.9	---	25
UCLM18	4	6	0.37	---	1.50	13.7	---	25
UCLM19	4	6	0.92	---	1.50	19.2	---	25
UCLM20	4	6	0.95	---	1.50	19.5	---	25

Workload weekly distribution

How the effort of the students is distributed along the course is a cornerstone of workload debates. The methodology discussed in the paper allows providing weekly statistics, e.g. γ for two modules over the approximately 15 weeks of the semester. In Fig. 6 this plot is presented, with one of the modules displaying a more homogeneous distribution of γ across the semester and the other showing peaks attributed to the extra workload close to exams, mainly at the end of the course. A similarly unbalanced weekly distribution was documented by Ruiz-Gallardo et al. (Ruiz-Gallardo et al. 2011) (see Fig. 1 in their paper). Joint distribution of the weekly workload across two or more courses could be investigated by looking at cross effects of concentrating the work during specific times in a certain course because of scheduled exams. This has been left for future work.

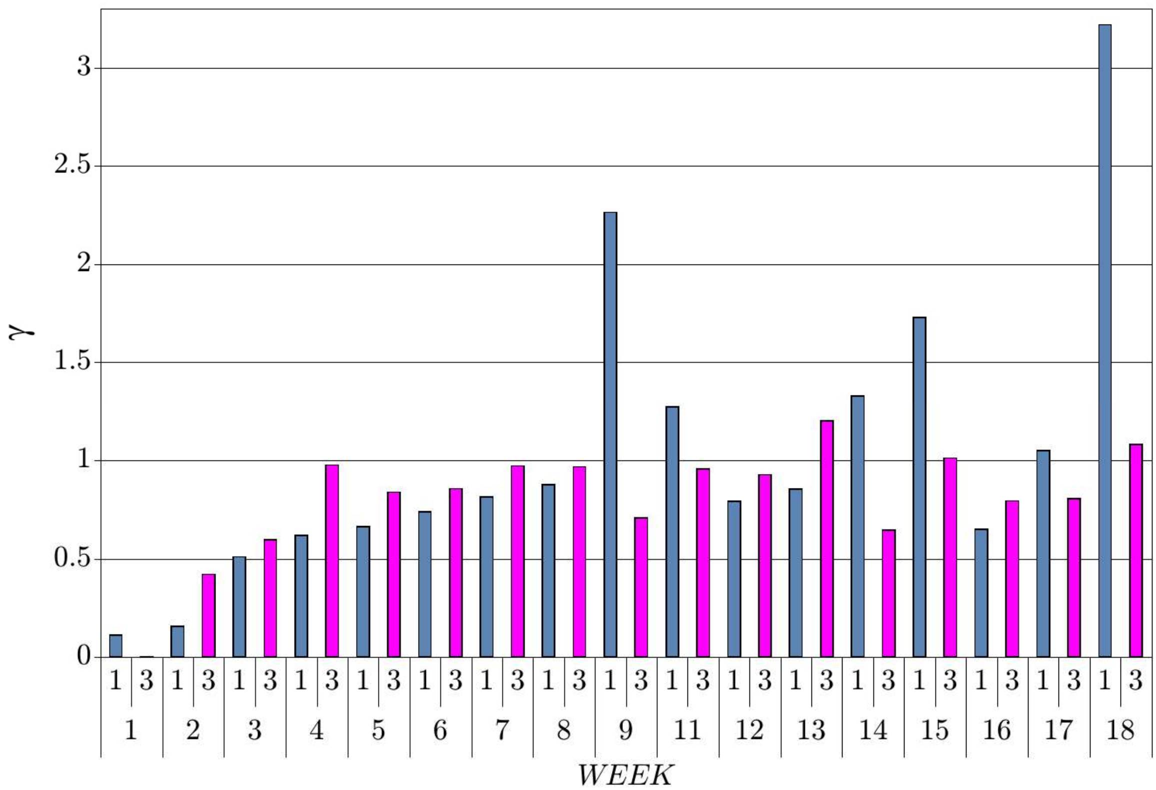


Figure 6. Weekly distribution of indicator γ for two UPM courses.

Discussion and conclusions

Now that the quantitative results have been presented, the research questions are revisited below.

Regarding the first question ("Is it possible to obtain a detailed description, collecting information in every contact session, of the workload of a moderately-large population of students, of the order of 500, in a set of courses?”), the answer is yes. The collection of information has been shown feasible by using an optical reader form with a simple design. This form considers only two categories for independent work: individual and team work. It also includes the date and duration of the contact activity in which the data is collected and the corresponding course. The form also includes the student identification, which allows linking workload and grades, as well as investigation of how workload is distributed in time. Moreover, it has been shown that the quality of the data is acceptable.

Regarding the second question (“Is it possible to conduct these measurements for an entire semester, so that measurements are not biased by effects that are localized in time?”), it has also been shown that it is feasible to conduct the measurements in the contact sessions of the monitored courses during the entire semester. In this way, inaccuracies due to misremembering the time dedicated to independent study are minimized. Moreover, measurements are not expected to be biased by the influence of effects localized in time (such as exams) and the measurements can be used to document significant changes in the workload patterns throughout the semester.

The measurements carried out within present initiative included 250,000 work hours from 1,400 different students. The amount of collected data is greater than previous workload measurement initiatives. For example, Schuman et al. (Schuman et al. 1985) considered a large population (500 individuals) but asked only “typical” weekly study hours; Kember et al. (Kember et al. 1996) monitored around 300 students asking them to fill out a detailed diary of activities during a single week; and more recently, Ruiz-Gallardo et al. (Ruiz-Gallardo et al. 2011) dealt with a 100-student course during three consecutive years, asking the students to keep account of their workload in that single course, and filling out a form to be handed in weekly. None of these initiatives used optical reader forms, a very convenient method for continuous workload monitoring of a large population in a range of courses.

Regarding the third question (“Is it possible to statistically characterize student workload by estimating cumulative distribution functions for raw and derived random variables?”), a set of random variables used as indicators to discuss the workload distribution have been introduced. They are obtained from the raw data obtained in the survey, i.e., the duration of the independent (out-of-class) work periods. The most relevant of the developed random variables are based on ratios of independent (out-of-class) versus contact (in-class) workloads. A framework to discuss these indicators has been established using a probabilistic approach, which is feasible due to the large amount of collected data. In our opinion such an approach is vital, considering the complexity of the phenomenon (student workload) and when large student populations are involved.

As a simple but relevant outcome from this framework, it has been shown, with consistent results in the two main populations considered (the UPM and UCLM faculties), that around one third of students attending any contact session may have not studied previous sessions’ materials. It is suggested to the reader to conduct a simple Bernouilli experiment consisting in checking this estimate by asking the students during any lesson.

Regarding the fourth question (“Is it possible to challenge, from such measurements, the idea of ECTS workload equivalence and consequently the established idea of equivalent ECTS credits modules implying an equivalent or at least similar workload?”), the developed indicators provide grounds for challenging such equivalence. First, the out- of-class vs. in-class single record ratio β median is of the order of 0.5 across the whole population compared to values around 1.5 representing the nominal ECTS ratio in the courses considered. Second, the variability of workload hours per ECTS was very large, with α ratio ranging from 0 to 2.8, and with the actual ECTS equivalence ranging from 10 to 26 hours for students that passed a well-documented course. Considering all these observations, the relevance of the ECTS metric in characterizing student workload is questionable.

Even though the inconsistencies mentioned are largely neglected by the university education executives, other authors have questioned the ECTS metric: Van-Damme (Van-Damme 2001) praised its simplicity while suggesting that, considering its limitations, it is unlikely to become the model for credit transfer on a global scale. The overestimation of the work done by students through the official ECTS ratio, was also documented in the studies of Krzin-Stepisnik et al. (Krzin-Stepisnik et al. 2007)(2007), who reported 13.6 h/ECTS, and Arana et al. (Arana et al. 2005) reported deviations in the order of 30%. There are also some studies that claim higher workloads than the suggested by the ECTS equivalence. Ruiz- Gallardo et al. (Ruiz-Gallardo et al. 2016) documented this while transitioning one course to Problem Based Learning methodology within an undergraduate program for Primary School Teachers. Kyndt et al. (Kyndt et al. 2014) interviewed forty Belgian Master's students (twenty from Educational Sciences and same amount from Civil Engineering) who consistently complained about the actual workload of some courses being largely underestimated compared to their nominal ECTS credits.

An aspect that has been highlighted in this study, and that has not been given attention in the literature, is the fact that modules with the same nominal ECTS credits and similar contact hours may lead to very different amounts of independent study. This again questions the ECTS metric, and at the same time, those methodologies that measure staff workload based on the ECTS credits of the courses.

It could be claimed that the issues raised about the ECTS metric are not to blame on the metric itself but on poorly motivated or steered students, on inadequately designed modules and/or other factors such as part-time jobs. However, without exploring the host of contextual factors that are likely to impact on hours of input from students the reasons cannot be establish but this is out of the scope of this paper. The ECTS credits should in principle indicate the amount of work necessary to accomplish the objectives of the courses. If that is not the case, the blame should be put somewhere else but not on the metric itself. While one cannot disagree with this idea, the problem with these arguments is that the metric remains a construction seen as a fully reliable mean to organize the students' workload, to measure the courses' workload, and even in some cases to characterize the teaching staff effort. However, the present study provides evidence indicating that actual scenarios may be difficult to fit within such a simplified framework. The authors believe that the paper outcomes may provide an increased level of awareness on student's workload and ECTS that, hopefully, can be helpful to fellow academics, who can contrast present research outcomes to their own experiences.

One additional result that deserves some comment is the low amount of teamwork, indicating that roughly 10% of the out-of-class work is carried out in groups. This suggests that teamwork is very weakly promoted by both institutions for the considered degrees, something that is true for many universities (Astin 1987). However, as aforementioned, "Teamwork" is one of the generic skills most valued by employers.

As a final thought, even with the criticisms posed in this paper on the ECTS totem pole, the authors acknowledge the groundbreaking contribution of the ECTS paradigm in promoting students' mobility (in Europe and beyond) by providing a consensual scheme for course recognition across different national university systems. The technicians and politicians who devised and implemented the ECTS scheme deserve recognition of the higher education community for such outstanding contribution.

Limitations

There are limitations of note in the present study. The results presented refer to the target population, a large number of students who are enrolled in two Engineering faculties of two Spanish universities, and for which the indicators take overall similar values. Our findings are thus limited to this students´ sample. Although we cannot make broad generalizations, we think it is important to draw attention to the results obtained, as they raise important considerations on the actual practice of students in regards to their effective workload, and how such workload is distributed across their university courses, considerations that could be useful for policy makers.

In addition, our findings are limited by our reliance on students reporting their workload through the continuous data collection during the monitored courses. Considering this, some readers may trivialize the results, attributing them to questionable accuracy. Although this argument may have some merit, the amount of information is so large and consistent that it cannot be taken lightly. Thus, we argue that the methodology implemented in this research has a value that outweighs its limitations. Attending to our present perspective is critical if we hope to equate the planned workload to the actual one with the ultimate goal of improving students' academic achievements.

Future research

This study also raises questions for future research. First, the present study, a quantitative method, may be a bit too constrained if compared to other noteworthy and inspirational mixed quantitative/qualitative methodologies cited in the literature review. It is left to future work to reflect on whether combining both methods is worth the effort.

Probability cumulative distribution and density functions for the indicators considered in this research have been proposed. They have been produced by post-processing the empirical cumulative distribution functions of these indicators. Further research is needed in order to propose meaningful and accurate analytical models for the density and cumulative distribution functions.

Whether students had previously failed a course and therefore took it for the second time has not -for the sake of brevity- been contemplated in this analysis and is left for future work, too.

It would also be interesting to investigate whether the smaller independent workload found in some of the modules, compared to others with the same nominal ECTS, has any effect on the students' rating of instructors, as explored in literature (Greenwald and Gillmore 1997; Jackson et al. 1999; Seaton et al. 1980; Toland and De Ayala 2005; Watkins and Gerong 1992). However, access to such ratings was not feasible within present study.

The database created through the initiative could be completed and used to investigate a few relevant aspects regarding workload, such as gender differences, impact of socio-economical characteristics on workload patterns, course design influence on workload statistics, how the workload patterns evolve as the students progress in their degrees, etc.

Finally, it would be interesting and necessary to draw definitive conclusions to have results from these institutions for other degrees and other institutions Spanish and European using this same methodology. Moreover, a more in depth study of the population of students that decides not to complete the survey needs further characterization. Additionally, a detailed study studying important workload factors need to be done.

The authors are keen to provide theoretical and practical support to lecturers interested in carrying out such initiatives. If the initiative were resumed at the same or different institutions, it could eventually be important to redesign certain aspects of the instrument.

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