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How much is much? Using smartphones to assess student (and course) performance

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Abstract

We used a smartphone application to track the work time of students. The study of the time distribution showed that freshmen tend to study at the very last minute, indicating a poor time management skills. For high-performance students, the grade was positively correlated with the time of study and the correlation found agrees with the recommendations of the Bolonia criterion.

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1. Introduction

Physics 101 can be challenging for undergrad students enrolled in Engineering (Duit, Niedderer & Schecker, 2007). As instructors of many courses, we frequently were answered to the "how much did you study?" question with a sincere "a lot" from baffled freshmen confronted with a bad grade, trying to appeal to the sensibility of the instructor to soften him. This question lingered on the back of our minds for many years, as it was difficult to properly track down the student performance. Recent advances on mobile technology had completely reversed the situation (Williams, 2012; Mora, Sancho-Bru, Iserte & Sánchez, 2012; Nirmalakhandan, 2009): powerful smart phones are ubiquitous (Csete, Wong & Vogel, 2004); we are seeing a tremendous growth of applications (apps) for virtually every conceivable task or purpose (Petropoulakis & Flood, 2008; Dong-Hee Shina, Youn-Joo Shina, Hyunseung Choob & Khisu Beomc, 2011). We propose the use of one of such applications, originally designed to track work performance, tricked to specifically track the study dedication. Results are in agreement with the guidelines outlined in the Bologna Declaration on the European Space for Higher Education (1999).

2. Methods

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The methodology proposed was implemented during one semester of Physics 101 course for engineering students. The course was divided on 14 weeks, 3.5 hours of lecturing per week. At the beginning of the semester, students were required to download and install a free app Time Recording Timesheet (https://play.google.com/store/apps/details?id=com.dynamicg.timerecording&hl=en) running under Android operative system (which was found to be by far the most common operative system running on their smart phones). We proposed the students to solve a list of problems. In such a way, each problem was treated as if it were a task, properly labelled, recording not only the date, but the total amount of time required to complete it and its degree of completion, from a scale of 3 values (non-completed, partially completed and fully completed). Using a tracking method was compulsory; therefore effectively enforcing the regular use of the app. Non mobile users or users of other operative system were given the chance to manually record their performance in Excel spread sheet. All Excel spread sheets were collected and processed at the end of the semester. 36 students completed the course, providing 20 valid spread sheets. Results revealed some interesting facts both in the student pattern of learning and in the course design, as explained in the following section.

To remove any spurious correlation, students must complete a questionnaire at the beginning of the course: a primary source of variability could be the path of entry: 65% come from high school, 29% from technical schools, and 6% were taken the course for second time. To account for possible inequalities in their education, they were asked if they attended a private (19%) or public (81%) high school, if students have taken Physics courses at high school (76%) or this was going to be their first contact with Physics (24%). Another source of variability could be when students were admitted to the University, 71% were admitted in July, while 29% in September. The next question asked was if they have taken extra lessons of Physics during the vacation time (thus providing them with a boost not accounted for): only 7% did while 93% did not. The level of education of their parents (college educated (24%), high school (21%) or elementary education (55%) of both parents) was also enquired on the grounds that students of a family with a higher level of education could be better equipped to face the changes. Students were also asked if they were working during the semester (33% have taken jobs, 77% were full time students), as performance could be resented by the mere fact that these students will have less time available and of poor quality, as fatigue may take its toll on the learning capabilities. Finally, students were asked if the study they were enrolled on was their first choice (79%), as we hypothesized that the motivation could be higher for students who are supposed to pursue their goals. None of the tested variables have shown any significant correlation against grades.

3. Results and discussion

We were expecting a correlation between the total time devoted to study and the final grade. Figure-1a plots the distribution of the total time of study of each student. Total time of study shows a wide dispersion, from a staggering 5566 minutes to a meagre 138 minutes, while most students devoted less than the mean of 1178 minutes. The distribution and the mean are distorted by the presence of two outliers. These outliers correspond to the students that were taking private tuition (thus being forced into a weekly routine of doing homework). The results could also check the validity of some claims. European Universities have implemented the principles and guidelines outlined in the Bologna Declaration on the European Space for Higher Education (1999). One criterion widely used to dimension the workload of a course states the equivalence of 1 hour of teaching to 1.5 hours of homework (Passolas, Cereceda, Bastero, Galán & Suárez, 2004). Applying this criterion to the presented course yields a workload of about 4410 minutes (i.e. a student working this amount of time should, under normal conditions, satisfactorily pass the course). The total time employed by the majority of students was consistently below this figure. We found that there is no significant correlation between the grade and the total time devoted to study.

We believe that trying to solve a problem does have a learning value, thus we expected that the higher the number of problems tried, the better the grade. Figure-1b plots the distribution of number of tried problems. The maximum performer tried 135 problems, the lower scorer attempted 18 problems, the mean being 61 problems. The number of problems solved for each student did not show a significant correlation with their grades either.

Discarded this correlation, the following most plausible explanation could be that only students that consistently and successfully complete tried problems will interiorize the required skills and knowledge, thus obtaining better grades. Efficiency is measured as a ratio of number of problems tried and completely solved to the total number of problems attempted. Figure-1c shows the distribution of efficiency of each student. The mean efficiency is 54 %, with a top performer scoring 93% and the worst performer 0.5%. Efficiency did not show any significant correlation with the grade.

A more detailed analysis of the student performance casts some light on this lack of correlation between total time and grade.

At the beginning of the semester, students were asked how much time per week they think they will honestly work. The question targets the degree of maturity and self-perception of the student capabilities. Figure-2 shows the frequency distribution in time intervals of this variable, along with the actual time consumed (for sake of comparison, both were converted to the same time interval). Clearly, the perception of their capacities is over estimated: the distribution of their actual performance is biased towards the left on the lower end with a mean of 1.4 hours per week, below of their initial estimations of their capabilities with a mean of 6 hours per week, which in turn is below the calculated value of 5.2 hours per week applying the Bolonia criterion.

The time per problem is defined as the total time of study divided by the total number of problems tried. It is a measure of the average time used to attempt a problem. It could be interpreted as a measure of the degree of persistency while trying a demanding task (solving a problem). Figure-3 plots the frequency distribution of the ratio for each student. The average time committed to solve a problem was 18 minutes, with a maximum time of 51 minutes and a minimum time of 6 minutes. The shape of the distribution is tilted towards the left, most likely indicating that most of the students gave up before satisfactorily completing the tried problem, while the presence of a handful of students to the right could indicate the presence of slow or very persistent learners. This ratio provides useful information to the instructor by giving a direct account of how much time consumed per problem, thus quantifying the estimated time required to complete any given amount of suggested problems.

A plot of the time distribution of the total time (in minutes) of study per each day of the entire class provided some hints on the study performance (Figure-4a). Students tended to postpone their study until the very last minute, with disastrous consequences. It began with a sluggish start of 30 days without any appreciable work (from the beginning of the course at day 255 until day 285). Peaks of workload were clearly evident, a first concentrated effort a few days before the partial exam (day 300), followed by another period of 25 days of low activity, indicating a possible conflict with other courses competing for resources (study time) of students, followed by a peak of similar magnitude in intensity and of two weeks of duration (days 326 to 340) before the winter break. Christmas holidays did not contributed significantly to the total amount of time consumed, followed by several weeks of constant activity culminated with a massive peak, last-minute effort at the end of the semester clearly dominating the time distribution. The number of students also follows the same temporal pattern (Figure-4b). Only a handful of students consistently work during the entire semester: intermittent effort, with bursts of two or three days of concentrated activity was the norm.

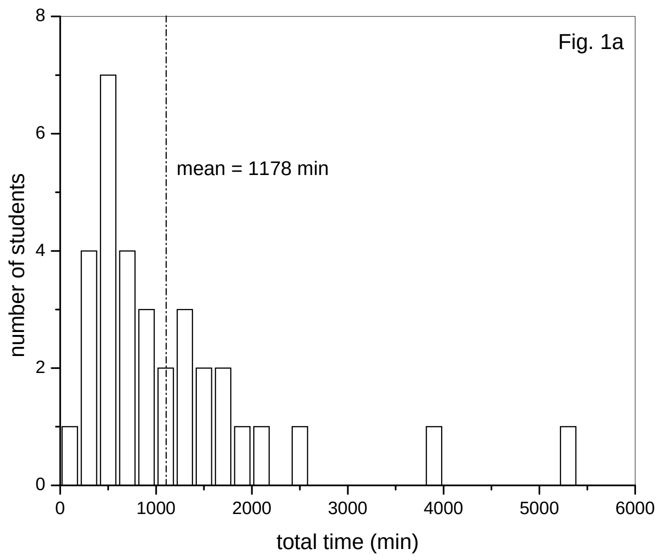
The temporal pattern of study forced students to choose among topics, concentrating their efforts into a few topics deemed to be the most likely to be tested on the final exam (students had records of previous tests at their disposal). Thus a probabilistic factor was added to the equation of success: students that did not work the topics asked on the tests, were simply doomed to fail. The final exam was composed of five problems, each one specifically designed to survey the knowledge of a given topic and accounting for 20% of the grade. A five points on a scale of ten points is the minimum required to pass the exam. These students that scored in less than three problems may selectively choose among which topics to study in a last-minute effort to pass the exam. To check this hypothesis, we removed from the original dataset all students that scored on less than three questions (regardless their score on each problem and the total time of study). Removing students that scored in less than 3 problems clearly enhances the correlation between total time and grade (R = 0.903) as seen in Figure-5. Total number of problems tried (R = 0.582) and efficiency (R = 0.532) showed weaker correlations with grade. Thus the key variable to explain the success of the students is the total time of study.

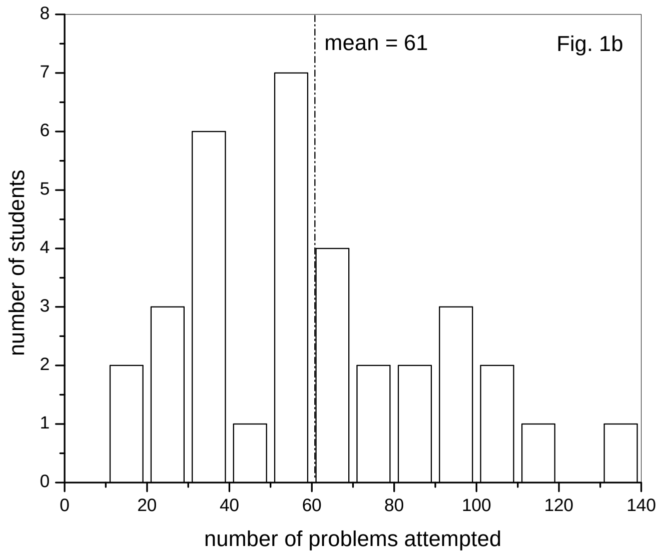
We obtained an equation that describes the required amount of time of study to successfully pass the course,

$$Grade = 3.22 + 0.00153 \cdot Total\ Time\ of\ Study \quad (1)$$

Total Time of Study expressed in minutes and *Grade* on a ten points scale. Students are now provided with a tool that precisely addresses the question of how much time is required to pass the course. As a final check of validity of the equation, setting the total time to 4410 minutes, the estimated workload for the course applying the Bolonia' criterion, yields a grade of 9.9, virtually a perfect score. The amount of 4410 minutes of study is equivalent to 9 days of 8 hours of continuous hard work per day. Looking back at the time distribution of the total time of study, it is evident that the strategy of massive two-last day effort to pass the exam is flawed.

A frequency distribution analysis of the problems attempted showed that only a tiny portion of available problems were explored by the students. Recommended bibliography was virtually ignored. Although working individually, students coincidentally flocked to the same type of exercises, mimicking the type solved in class. From the student point of view, efficacy means to pass the exam (short-term goal), while for the instructor it means to satisfactorily acquire capacities, skills and knowledge (long-term goal). This divergence of objectives will result in a different learning technique.





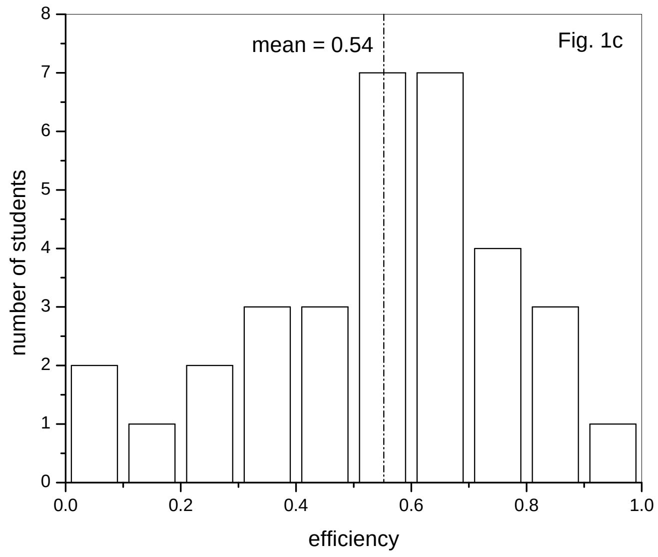


Fig. 1. (a) number of students versus total study time; (b) number of problems attempted; (c) efficiency

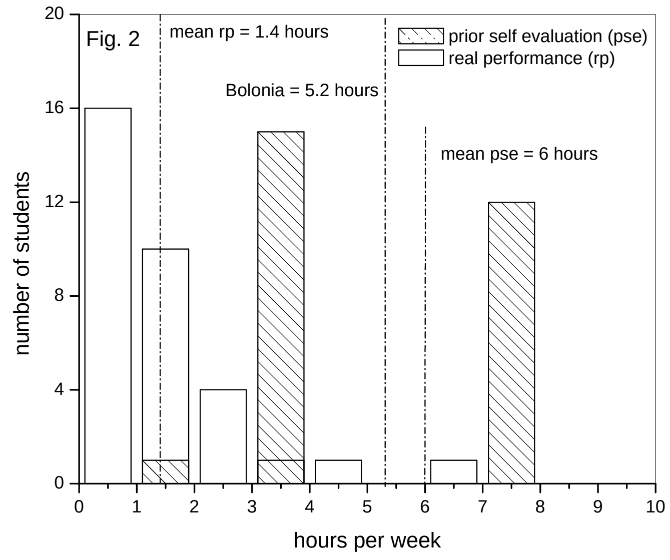


Fig. 2. number of students versus hours of study per problem

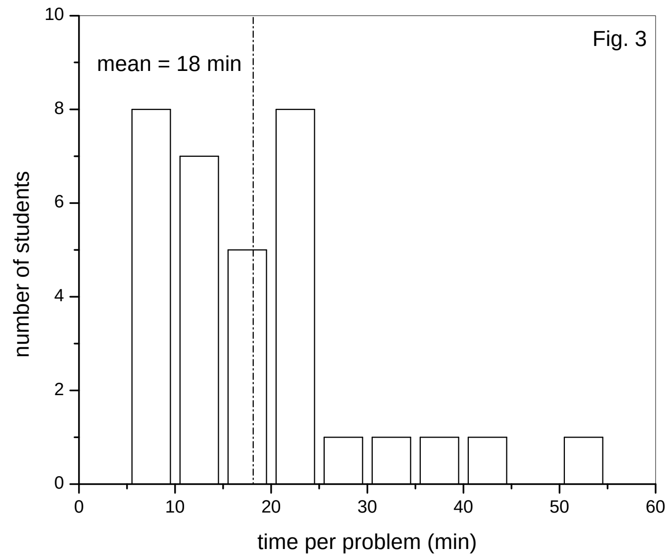


Fig. 3. number of students versus time of study per problem

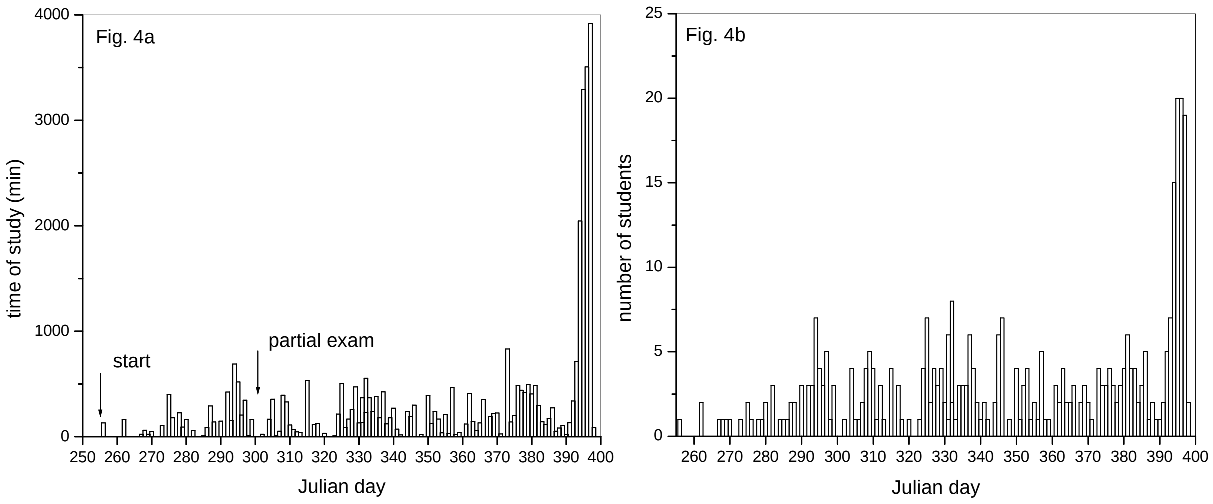


Fig. 4. (a) time of study versus day; (b) number of students studying versus day

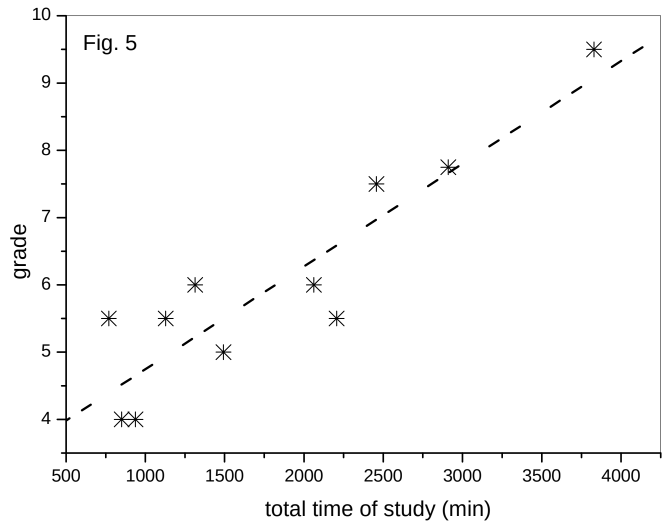


Fig. 5. Grade versus total time of study for high-performance students

4. Conclusion

Using smart phones to track down performance has proven to be very fruitful, sometimes in unforeseen ways. Students can raise their awareness of their actual workflow, time effort and meaning of learning. The experience was also very positive from the instructor perspective: it revealed hidden patterns in the design of the course layout, prompting for a better distribution of time.

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