



**The Use of an Active Learning Approach to Teach
Metabolism to Students of Nutrition and Dietetics**

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5 **The Use of an Active Learning Approach to Teach Metabolism to Students**
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53 **Key words:** Metabolism, Active learning, Nutrition and Dietetics, Moodle
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ABSTRACT

This article describes the transition from a traditional instructor-centered course, based on lectures, to a student-centered course based on active learning methodologies as part of the reform of the Spanish higher education system within the European Higher Education Area (EHEA). Specifically, we describe the use of active learning methodologies to teach metabolism to students of nutrition and dietetics during the first year of their professional training in a 4-year undergraduate degree (Bachelor of Human Nutrition and Dietetics). In the new course design, the number of didactic lectures was largely reduced and complemented with a series of activities (problems/case studies, discussion workshops, self-assessment quizzes) aimed to get students actively engaged, to encourage self-learning, and to promote sustained work throughout the length of the course. The article presents quantitative data demonstrating a clear and significant improvement in students' performance when an active approach was implemented. Importantly, the improved performance was achieved without work overload. Finally, students' responses to this new teaching methodology have been very positive and overall satisfaction very high. In summary, our results strongly argue in favor of the teaching model described herein.

INTRODUCTION

In 1999, thirty European countries engaged in a voluntary process to create the European Higher Education Area (EHEA) which was formalized in the Bologna Agreement [1]. The EHEA was meant to ensure more comparable, compatible and coherent systems of higher education in Europe. In addition to changes in structure of higher education systems, the Bologna Process called for a deep change in the approach to education, involving a shift from instructor-centered to student-centered learning [2], as exemplified by the adoption of a credit system (ECTS, European Credit Transfer System) based on students' workload. In this context, the Bachelor of Human Nutrition and Dietetics at Universidad Autónoma de Madrid (UAM) has evolved from a 3-year to a 4-year undergraduate degree (240 ECTS), and the contents of the former one-semester course of Biochemistry (course ID 14841) have been segregated into two different but related courses: General Biochemistry (course ID 18425) and Metabolism (course ID 18427) (Fig. 1).

The former Biochemistry course was a classical instructor-centered course based on information delivery in face-to-face and did not encourage student self-directed learning. The assessment of student learning was through three written tests that covered specific subsets of the curriculum and a final exam, that covered the whole course content, and accounted for 75% of the final grade. Traditionally, performance in Biochemistry used to be very poor with, for example, 65% and 52% of students passing the 2008/09 and 2009/10 courses, respectively. Herein we describe the design of a new teaching methodology and the results obtained in the first two academic years after its

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5 implementation. Our data reveal improvement on student performance suggesting that
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7 the new methodology results in corresponding learning gains.
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10 11 12 13 **MATERIALS AND METHODS**

14 15 16 **Course design and assessment methodology**

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19 The course was organized in six units of different length (Fig. 2): (i) introduction and
20 basic thermodynamics, (ii) bioenergetics, (iii) metabolism of carbohydrates, (iv)
21 metabolism of lipids, (v) metabolism of amino acids and nucleotides, and (vi)
22 integration of metabolism. Broadly, we set the learning goals so that, by the end of the
23 course, the students were expected to understand the metabolism of nutrients in
24 different organs and physiological situations and be able to apply that knowledge to
25 predict the effect of metabolic disorders or nutritional interventions (detailed objectives
26 of the course are provided in the supplementary material). For the course design we
27 followed a strategy, similar to the one suggested by Fink [3], based on a sequence of in-
28 class and out-of-class activities (Fig. 2) that built on each other. Specifically, each unit
29 was started with an introduction to the topic in the form of a small number of didactic
30 lectures (between 3 and 6) and then continued with a series of out-of-class activities,
31 including a number of assignments (Fig. 2). Finally, in-class sessions were scheduled
32 after the deadline of assignments to solve students' questions and provide feed-back.
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34 The arrangement of these different learning activities (instructional strategy), as
35 depicted in figure 2, was repeated for all the units throughout the course. Importantly,
36 and in sharp contrast to previous Biochemistry courses, a large proportion of in-class
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5 sessions were devoted to activities other than lecturing such as discussion and
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7 answering students' questions (54% in Metabolism as compared to 16% in
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9 Biochemistry). To engage students in a higher level learning we chose a variety of
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11 activities, rather than focusing on a single one [4], as follows:
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15 1. Problems and case studies workshops. Distribution of numeric problems and case
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17 studies that led to some insight relevant to nutrition or dietetics (Fig. 2) to be
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19 submitted electronically, followed by in-class resolution guided by volunteering
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21 students (see supplementary material for an example).
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25 2. Discussion workshops. Distribution of three questions, intended to invoke reasoning
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27 and integration of different concepts, to be submitted on-line as a short essay (Fig.
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29 2, "discussion topics"). Answers revealing common misinterpretations of concepts
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31 or flaws in reasoning were used as the starting point for discussion between students
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33 in a specific in-class session (see supplementary material for an example).
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37 3. Self-assessment quizzes. Self-marked quizzes containing multiple choices, matching
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39 or embedded answers (Cloze/gap fill) questions. Wrongly answered questions
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41 resulted in automatic feed-back with a detailed explanation of why the chosen
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43 option(s) was(were) incorrect. Quizzes remained available throughout the course so
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45 students could retake them at anytime to keep track of their progress.
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49 4. Tutorials. In-class sessions to solve any question or doubt that the students might
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51 have just before a unit quiz.
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5 5. Unit quiz: It was done individually on-line during an in-class session and consisted
6 of multiple choices, matching and embedded answer questions. The unit quiz was
7 solved in the next session (Fig. 2) by students with instructor's help.
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16 The assessment of student learning was completed with a written test at the end of
17 the course (final exam) that accounted for 60% of the final grade (the minimum allowed
18 by University policy on student's assessment). The final exam covered the whole course
19 contents and the number of questions of each unit was proportional to the length of that
20 unit in the curriculum. Exam questions demanded the recall and the application of
21 factual and procedural knowledge (in the form of problems and cases to solve) aligned
22 with the course objectives and activities. In order to test the convergence of validity
23 between different assessments, we compared the scores of the final exam to the
24 weighted average scores of the unit exams (unit quizzes). As shown in supplementary
25 figure 1, there is a strong (0.81 Pearson's correlation coefficient) and significant
26 ($p < 0.001$) correlation between both scores suggesting that the final exam score is a
27 reproducible measure of students' performance. Besides the final exam, and faithful to
28 the spirit of the EHEA, continuous assessment (unit quizzes and all online activities)
29 contributed 40% to student's grade. Specifically, 30% of the final mark was calculated
30 as the weighted mean of the grades obtained in the unit quizzes (activity 5), being the
31 weight proportional to the unit length. An additional 5% of the final grade was
32 calculated as the average of grades obtained in the assignments corresponding to
33 activities 1, 2 and 3. The remaining 5% of the final mark accounted for the participation
34 during in-class discussion and problems workshops. This mark was determined at the
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5 end of the course based on the subjective instructor's criteria. The relatively low
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7 contribution of each individual assignment to the final mark, in particular those
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9 corresponding to activities 1-3, relieved the pressure on students so they could really
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11 focus on learning and freely expose what they did not understand, rather than getting a
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13 good grade. Finally, in an attempt to compensate for the small contribution of each
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15 assignment to the final grade and to promote sustained work, students were required to
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17 complete 80% of the assignments (activities 1, 2, 3 and 5) to pass the course.
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20 21 **Moodle Platform**

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24 All the course activities were managed through the platform Moodle (Modular
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26 object-orientated dynamic learning environment, [5]). Moodle was of key importance
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28 for this course as it was used not only for access to all teaching materials related to the
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30 course, but also to conduct on-line assignments (quizzes), provide extensive feedback to
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32 wrongly answered questions in quizzes, show student progress (gradebook), provide
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34 instant grading, answer questions, post announces (forums) and ask for students'
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36 opinion (surveys).
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39 40 **Statistical Analysis**

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43 All statistical analyses were conducted using the R software [6]. Data in figures 3 and
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45 4 are represented in the form of "violin plots" [7] a type of graph that combines a classic
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47 box plot (black boxes) and the frequency of the data at different values (shape overlaid
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49 on the box plot). Effect sizes were calculated as the difference in the means of two
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51 populations divided by the pooled standard deviation of both populations [8].
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RESULTS

As a starting point to assess the impact of the new teaching approach we decided to compare the performance of students in the two academic years 2010/11 and 2011/12, that followed the novel teaching methodology described in Materials and Methods to that of students in the two previous academic years (2008/09 and 2009/10) who received a traditional education. As shown in table I, the majority of students passed the 2010/11 and 2011/12 Metabolism courses (85% and 93% respectively) while results for 2008/09 (65%) and 2009/10 courses (52%) were significantly poorer. However, it could be argued that these results are a consequence of the different assessment method and/or curriculum between these courses. Thus, to overcome, at least in part, the effect of these variables, we compared the pass rates based in the final exam only. The final exam was quite similar in all four courses being a high-stakes test that had a major impact in both passing the course and final mark. The final exams were also similar in format and content as they were designed to assess the acquisition of a common set of concepts and skills (the learning goals were identical in all four courses). Moreover, for the courses 2008/09 and 2009/10, we calculated the passing rates only taking into account the questions of the exam that covered the contents that were common to all four courses under study. Metabolism questions comprised 51% and 57% of the final exam in the 2008/09 and 2009/10 courses respectively, reflecting the proportion of the course devoted to the metabolism module. Thus, given the weight of the final exam on the course grades, the metabolism questions had a large impact on the overall course grade. Table I shows that, taking the final exam as reference, the rate of success was 90-93% in

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5 the courses 2010/11 and 2011/12 as compared with the 38-47% observed in previous
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7 courses.

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10 Importantly, students' profile was similar in all four years evaluated (table II)
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12 arguing against it as an explanation for their different performance. Specifically,
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14 differences in either gender or previous studies, including grades for access into the
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16 Bachelor of Human Nutrition and Dietetics were statistically non-significant.
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20 Although Metabolism is a new curriculum, it is important to note that the contents of
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22 this course and the depth in which they are covered are not significantly different to the
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24 module devoted to metabolism in the former course of Biochemistry. Thus, we believe
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26 that the comparison between courses is a fair indication of whether there were
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28 improvements in performance using the new teaching methodology compared with the
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30 former conventional lecture course of Biochemistry. However, as the assessment
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32 methodology in both courses was significantly different we sought to design an
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34 experimental setup that allowed us to have a more objective comparison. For that
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36 purpose, we asked our 2010/11 and 2011/12 students to solve the metabolism test
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38 questions that were given to their student colleagues of the 2009/10 Biochemistry
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40 course as their final exam. It is noteworthy that students were only informed about this
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42 experiment on the very same day of their own final exam and, those students willing to
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44 participate in the experiment, had to complete this experimental test right after
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46 submission of their own course final test. We detailed the reasons for this experiment
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48 and stressed that the participation on this experimental test was strictly voluntary and
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50 had no impact on their course grade. In fact, the experimental test was only available
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52 after they had submitted their final exam so by then, they already knew their official
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5 grade. Importantly, in spite of these conditions, which implied a really large altruistic
6 effort on their part, a large proportion of the students (25/36 in the 2010/11 course and
7 33/52 in the 2011/12 course) chose to take the experimental test. We interpret this large
8 participation ratio as an indication of the high degree of commitment of the students.
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15 The results from this experiment clearly confirmed the much better performance of
16 the students that received the active learning-based courses (Fig. 3). Specifically, the
17 percentage of students that passed this exam increased from 47% in 2009/10 to 88% and
18 87% in 2010/11 and 2011/12 courses, respectively. Figure 3A shows the distribution of
19 grades (range 0-10). The mean score was 4.9 for 2009/10 compared with 7.1 for
20 2010/11 and 6.6 for 2011/12, while the medians were 4.5, 6.9 and 7.0, respectively (Fig.
21 3A). Quantification of the impact of an intervention is usually done using effect sizes
22 (see materials and methods section). In our case, the effect size is 0.74-0.95 which is
23 surprisingly large [8]. Since not all 2010/11 and 2011/12 students participated in the
24 experiment, it could be argued that this result could be biased as only the most
25 motivated and/or best students took this experimental test. We disregard this possibility
26 as the proportion of students that took the test was very large (69% and 63%,
27 respectively) and, in addition, the mean grade of the students that participated in the
28 experiment was not significantly different to that obtained by the whole class in their
29 final test of Metabolism (Fig. 3B). Moreover, we found a significant correlation
30 between the grade obtained by the students of the 2010/11 and 2011/12 courses in the
31 experimental test and their own final test (supplementary figure 2). Altogether these
32 results strongly support that the performance of the students exposed to the new
33 teaching methodology is clearly improved. Nevertheless, it is important to keep in mind
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5 that the students who took this experimental test were self-selected and thus we should
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7 be cautious in the generalization of these results. In addition, although none of the
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9 experimental test questions were used in any of the activities during the courses and
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11 students of the course 2009/10 only saw these questions in their final exam, we cannot
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13 completely rule out that they might have circulated among the students.
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17 As a final measure of the impact of the new methodology on the students' learning
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19 experience, we decided to collect students' opinion by means of an anonymous survey,
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21 taken at the end of the semester. The questions were designed to gather information
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23 about the teaching/assessment methodologies, usefulness of the different activities, and,
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25 in particular, the workload they had supported as it could be argued that the increase in
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27 performance might require excessive work by the students.
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31 Metabolism is a 6 ECTS course equivalent to a total of 150 hours student's work. Of
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33 those, approximately one third (51 h) correspond to in-class sessions while two thirds
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35 (99 h) should be student's work outside the classroom. To assess whether we were
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37 overloading the students, we asked them to estimate how long they dedicated to the
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39 different course activities. The analysis of students' answers (table III and figure 4)
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41 revealed that the time they spent in each of the activities do not differ significantly from
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43 those expected in the class syllabus. Importantly, as the number of students taking the
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45 survey was large (n=28 and n=29) the reported workload can be considered
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47 representative. Thus, we conclude that students did not dedicate to our course longer
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49 than allocated for a 6 ECTS worth course.
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DISCUSSION

In this article we have described the transition from an instructor-centered course based on lectures (Biochemistry) to a student-centered course (Metabolism) based on active learning methodologies and the impact of this change on students' performance. Our results strongly support that the implementation of active learning in Metabolism resulted in a large improvement in both pass rates and overall grades. Importantly, we found that these results were achieved without overloading the students. Thus, a further important conclusion derived from this analysis is that the benefits of active learning are not at the cost of an excessive student workload. We think this latter result is highly relevant since, to our knowledge, this aspect is not usually addressed in the evaluation of active-learning approaches, in spite of its unquestionable importance.

Importantly, the students were highly motivated by this teaching methodology and when questioned about the teaching approach, 88-96% of the students believed that the student-centered methodology was better (they specifically indicated that they had "learned more") than a more classic instructor-centered methodology, based on lectures. In addition, 90% of students agreed that what they learned in the course was to be useful for their professional life. They also commented that the teaching approach used in Metabolism helped them between "quite much" and "a lot" to study daily, understand the course contents, relate different parts of the course, and apply what they learned to relevant clinical cases in Nutrition. Thus, the subjective opinion of students suggests that their learning experience under this methodology was very positive. We consider that student's satisfaction with active learning methods is, in a large extent, the driving force after excellent academic results.

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5 There are, however, some unanswered questions. One of them is whether the
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7 successful results are, at least in part, consequence of the novelty of both course and
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9 method to the students, the so called “Hawthorne effect”. Obviously, we will need to
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11 run the course for several years to obtain a solid answer to that question. However, after
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13 running the course for two academic years, we found no significant differences between
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15 the first and second editions neither in performance (table I and figure 3) nor in student's
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17 satisfaction, arguing against that possibility. A further concern is that the comparison
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19 between Biochemistry and Metabolism could be biased due to the different content of
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21 these courses. Since Metabolism comprises only a subset (about 60%) of the
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23 Biochemistry contents but both courses are a semester long, students of Biochemistry
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25 had proportionally less time to prepare the shared contents. This factor doubtless affects
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27 the comparison between courses and must be taken into consideration when analyzing
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29 the data presented herein. However, it is unlikely that this factor alone can explain our
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31 results as the performance of students in General Biochemistry that covers the contents
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33 of Biochemistry not included in Metabolism did not match that found in Metabolism.
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35 As General Biochemistry follows a traditional teaching method, we take it as strong
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37 indication pointing at the teaching methodology as the major factor explaining the
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39 increased performance. A further aspect to consider is that the ratio student to instructor
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41 was slightly higher in 2008/09 and 2009/10 courses as compared to the latter courses,
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43 which could have an impact in learning. Likewise, we cannot completely rule out that
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45 the larger number of students in 2008/09 and 2009/10 courses may affect performance.
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47 However, we find it unlikely since the number of students in General Biochemistry was
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49 identical to that in Metabolism whereas the performance was closer to that in
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5 Biochemistry. Finally, our conclusions are based on the premise that the groups under
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7 study were relatively homogeneous. The available data (table II) supports this
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9 assumption since the gross academic indicators, such as previous studies and access
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11 grades, were not significantly different. However, it is clear that other variables,
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13 including socio-economic status and motivation, would affect student's performance. As
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15 we have no access to such information we cannot formally rule them out as potential
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17 factors influencing our results.
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21 There are many reports supporting the benefits of active learning (see [9] for a
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23 review and [10] for a recent work in the context of the EHEA). However, in spite of
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25 this, a recent study in a US public university showed that lecture continues to be the
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27 primary method of instruction in detriment of active learning alternatives [11]. This was
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29 also one of the conclusions of the Teagle Working Group for the American Society for
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31 Biochemistry and Molecular Biology [12] that, in consequence, recommended “Work to
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33 publicize broadly those innovative, effective pedagogies that are already in use in the
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35 Biochemistry and Molecular Biology community”. For these reasons we think that our
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37 results, reported herein, could contribute to encourage colleagues from our area of
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39 knowledge to incorporate active-learning techniques in their courses.
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55 our 2010/11 and 2011/12 courses for their participation in the voluntary survey and the
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5 experimental test. Their altruistic cooperation allowed us to extract meaningful
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7 conclusions that will benefit their fellow students in future editions of the course. We
8
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34 article.
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REFERENCES

[1] The European Higher Education Area: Joint Declaration of the European Ministers of Education (Bologna Agreement): www.ntb.ch/SEFI/bolognadec.html (1999).

[2] The official Bologna Process website: <http://www.ehea.info/Pdfhandler.ashx?PdfUrl=http://www.ehea.info/article-details.aspx?ArticleId=11> (2010-2012)

[3] Self-directed guide to designing courses for significant learning: <http://sites.google.com/site/demovt/c/best-practices-scholarship/course-design-best-practices-files/FInkSelf-directedICDguide.pdf> (2005)

[4] M. J. Costa, P. K. Rangachari (2009) The power of interactive teaching, *Biochem. Mol. Biol. Educ.* 37, 74-76.

[5] Moodle: <http://www.moodle.org>

[6] R: A Language and Environment for Statistical Computing. R Development Core Team, R Foundation for Statistical Computing: <http://www.R-project.org>

[7] J. L. Hintze, R. D. Nelson (1998) Violin Plots: A Box Plot-Density Trace Synergism, *The American Statistician* 52, 181-84.

[8] M. A. Albanese, S. Mitchell (1993) Problem-based learning: a review of literature on its outcomes and implementation issues, *Acad. Med.* 68, 52-81.

[9] M. Prince (2004) Does active learning work? A review of the research, *J. Engr. Education* 93, 223-231

1
2
3
4
5 [10] P. del Canto, I. Gallego, J. M. López, E. Medina, F. Mochón, J. Mora, A. Reyes, E.
6
7 Rodríguez, E. Salami, E. Santamaría, M. Valero (2011) Follow-up and feedback
8
9 processes in the EHEA, Journal of Technology and Science Education 1, 12-23.
10

11
12 [11] W. J. Lammers, J. J. Murphy (2002) A Profile of teaching techniques used in the
13
14 university classroom: a descriptive profile of a US public university, Active Learning in
15
16 Higher Education 3, 54-67.
17

18
19 [12] Teagle Working Group for ASBMB Biochemistry/Molecular Biology and Liberal
20
21 Education: A report to the Teagle Foundation:
22
23 [http://www.asbmb.org/uploadedFiles/ProfessionalDevelopment/Resources/Teagle%20Report\(1\)](http://www.asbmb.org/uploadedFiles/ProfessionalDevelopment/Resources/Teagle%20Report(1).pdf)
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25 [.pdf](http://www.asbmb.org/uploadedFiles/ProfessionalDevelopment/Resources/Teagle%20Report(1).pdf) (2008)
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FIGURE LEGENDS

FIG. 1. **Courses that belong to the area of Biochemistry in the former and new Bachelor of Human Nutrition and Dietetics.** CRDT: Former credit system that only accounted for in-class hours (1 credit = 10 h), ECTS: European credit system that accounts for total students' workload (1 ECTS = 25 h).

FIG. 2. **Scheme showing the general instructional strategy for each unit in the course Metabolism (18427).** The graph represents a “castle top”-like diagram [3] of the planning for each unit in the course. The bottom part of the graph (yellow background) contains the planned activities for in-class time (each one lasting 50 minutes), the middle part (blue background) contains the planned activities for out-of-class time and the upper part (no background) contains the specific assignments. In each level boxes represent a single activity or piece of course work. The number on the right of the boxes (e.g. “x1”) indicates the times the activity indicated in the box is repeated in each course unit.

FIG. 3. **Performance of 2010/11 and 2011/12 students on a quiz based on the 2009/10 final exam.** (a) Distribution of grades obtained by students of the 2009/10 (n=76), 2010/11 (n=25) and 2011/12 (n=31) courses. The shape of the violin plots represent the frequency of each grade, the black box inside the shapes represents the second and third quartiles, and the white dot the mean. The difference in grades between the 2009/10 group and either the 2010/11 or 2011/12 groups is statistically

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5 significant ($p < 0.001$; Wilcoxon rank sum test with continuity correction). (b)
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7 comparison of the final grades in courses 2010/11 and 2011/12 obtained by the group of
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9 students who took the quiz based on the 2009/10 final exam (“Subset”) and the whole
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11 class (“All”). Data is represented as in (a). No statistically significant difference
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13 between both groups ($p > 0.05$; Wilcoxon rank sum test with continuity correction) was
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15 found.
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21 **FIG. 4. Student's workload per course.** Violin plots represent the distribution of total
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23 workload (other than classroom time) per course as stated by students in the course
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25 survey ($n=28$ and $n=29$ for 2010/11 and 2011/12, respectively). The horizontal red line
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27 marks the expected out of class workload according to the course syllabus (99 hours).
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29 The mean workload declared by students does not significantly differ from the expected
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31 value ($p > 0.05$, Wilcoxon-Mann-Whitney test) even assuming normally distributed
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33 values ($p > 0.05$, one sample student's t test.).
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TABLE I

Academic results

Course	Pass rate (course) ¹	Pass rate (Final Exam) ²
2008-2009	56/86 (65%)	33/86 (38%)
2009-2010	46/88 (52%)	42/88 (48%)
2010-2011	34/40 (85%)	35/39 (90%)
2011-2012	51/55 (93%)	51/55 (93%)

¹Number of students that passed the course/number of students that stayed in the course (percentage of pass). Differences in proportions between courses are statistically significant (p -value <0.001 , Fisher's exact test).

²Number of students that passed the final exam (mark equal or greater than 5 over 10)/number of students that stayed in the course (percentage of pass). Differences in proportions between courses are statistically significant (p -value <0.001 , Fisher's exact test).

TABLE II

Students' profiles in the four courses under study

Course	n	Gender ¹		Age ²	Previous studies			
		female	male		secondary education ³	vocational training ³	other/no data ³	average grades ⁴
2008/09	109	87	22	20.7±4.5(19)	90	18	1	9.24±0.98(8.86)
2009/10	105	87	18	21.6±5.4(20)	87	15	3	9.08±1.11(8.76)
2010/11	44	35	9	20.3±4.2(18)	31	12	3	8.95±1.20(8.75)
2011/12	56	48	8	19.8±3.9(18)	48	8	2	9.35±1.40(9.07)

¹We found no significant differences in gender proportion between courses (p-value>0.05, Fisher's exact test)

²Numbers indicate average age (in years) ± standard deviation (median). There is a significant difference between courses 2009/10 and both 2010/11 and 2011/12 (p<0.05, Kruskal-Wallis rank sum test followed by pairwise comparison with a Mann-Whitney test with Bonferroni correction).

³Number of students in each of the indicated categories of previous studies. We found no significant differences between courses (p-value>0.05, Fisher's exact test) in regard to previous studies. "other/no data" records the number of cases for which we lack the information regarding their previous studies and those reporting other than "secondary education" or "vocational training".

⁴Numbers indicate average grades for access into the Bachelor degree (in scale 0-14) ± standard deviation (median). We found no significant differences between courses (p-value>0.05, Kruskal-Wallis rank sum test).

TABLE III
Student's workload

Task	Hours ¹		n ²		Total hours ³		Syllabus ⁴
	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	
Study	3.0	3.0	14	14	42.0	42.0	48
Self-assessment quizzes	2.0	2.0	5	6	10.0	12.0	51
Problems/case studies workshop	2.0	2.0	5	5	10.0	10.0	
Discussion workshops	2.5	2.0	5	5	12.5	10.0	
Unit quizzes	6.3	5.0	4+1	4+1	31.3	25.0	
Sum					105,8	99.0	99

¹The time required for the students to complete each task was computed as the median of the hours declared by the students in the survey. In the case of "Study" the students were asked the amount of time, per week, they spent studying course contents and not included in other tasks.

²Represents the number of repetitions of a given task during the course. In the case of Study n is the number of course weeks. We included the final exam as an additional "unit quiz" to compute student workload.

³Hours spend on each task during the course (Hours x n).

⁴Expected hours to complete each task according to the syllabus.

FORMER DEGREE OF HUMAN NUTRITION & DIETETICS				NEW DEGREE OF HUMAN NUTRITION & DIETETICS			
CODE	SUBJECT	YEAR/ SEMESTER	CRDT	CODE	SUBJECT	YEAR/ SEMESTER	ECTS
14841	BIOCHEMISTRY	1/ AUTUMN	7	18425	GENERAL BIOCHEMISTRY	1/ AUTUMN	6
				18427	METABOLISM	1/ SPRING	6

figure 1
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For Peer Review

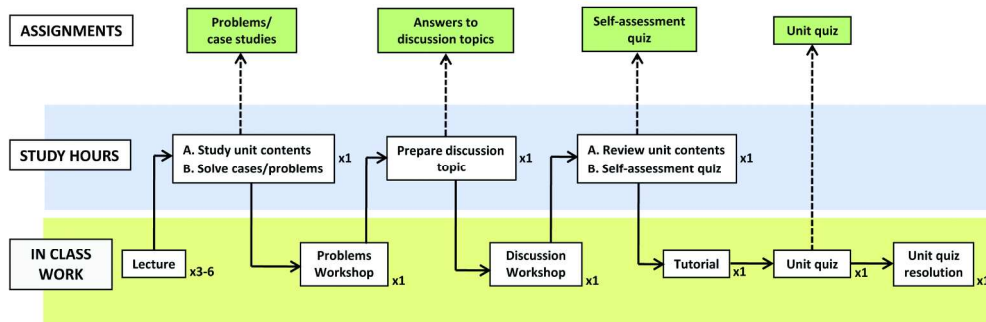


Figure 2
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or Peer Review

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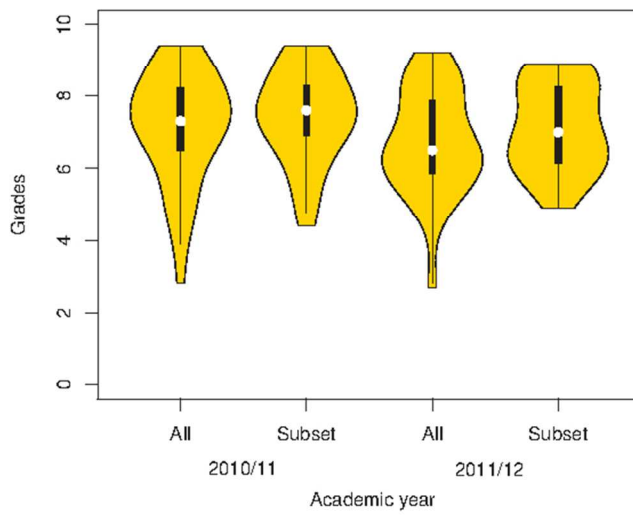
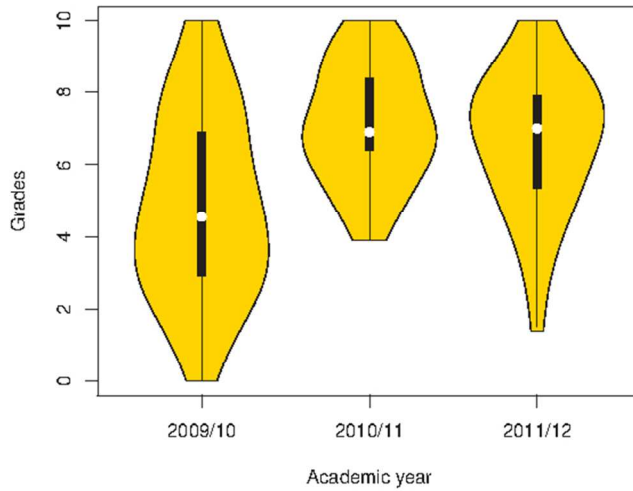


figure 3
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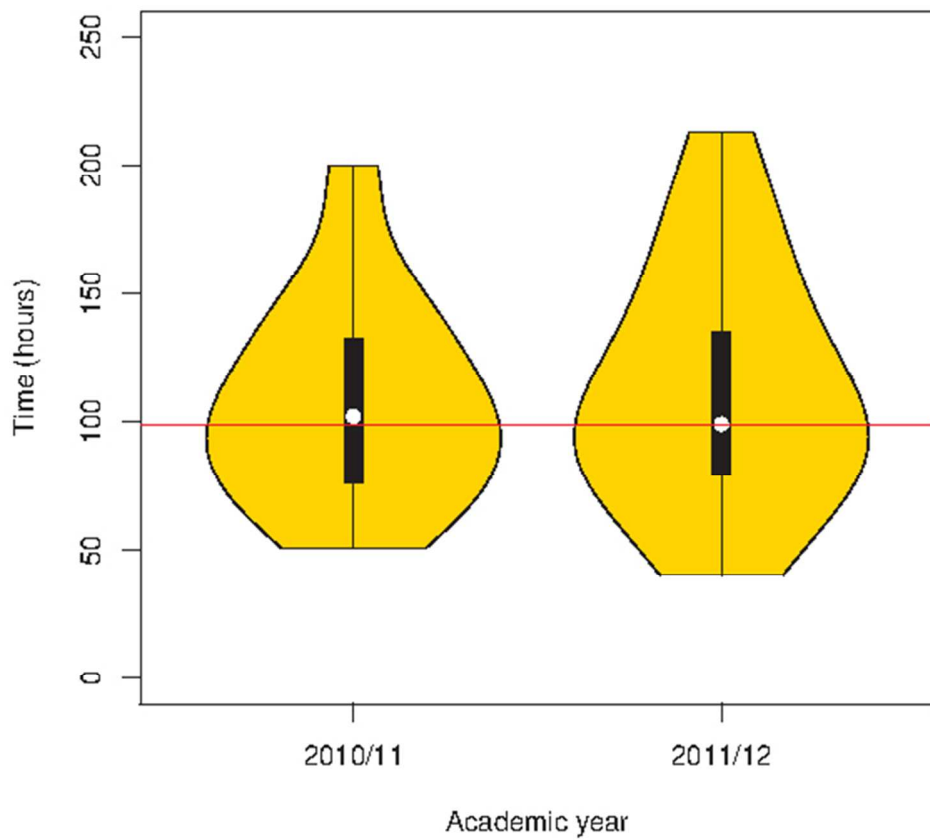


Figure 4
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