Question solving-based learning in higher education course of Biochemistry

Guido Santos, Carolina Pérez.

Departamento de Bioquímica, Microbiología, Biología Celular y Genética. Universidad de La Laguna. San Cristóbal de La Laguna. Spain.

ABSTRACT

Active student-centered teaching makes its way as a paradigm shift in university education. This methodology is the one that the evidence accumulated in pedagogical and neuropsychological studies shows as the only effective. A change in the teaching structure and organization of the subjects is necessary, especially in science, to adapt them to this approach. We proposed the design and delivery of theory sessions based on solving questions. These questions will be solved independently or in groups by students. The resolution of these questions will imply the acquisition of a series of concepts not explained by the teacher. Here we present a module of active teaching based on solving questions that is exportable to any science subject.

Keywords: question solving, active learning, biochemistry, higher education, evidence-based teaching.

1. INTRODUCTION

Active learning is the main approach on student-centered teaching. Evidence-based teaching suggest that this is the most efficient pedagogic approach[1]. This differs from the traditional professor-centered system based on lectures and memory centered exams[2]. Active learning requires programming a set of activities that force students to take an active role. There are several methodologies that follow this approach: problem-based learning, cooperative learning, peer instruction, etc. Here we propose a methodology based on question solving for a course of Biochemistry in the Degree of Biology.

Biochemistry presents a tradition of difficulty for the students of Biology due to the level of abstraction required. We have implemented in the past other student-centered modules in this subject with positive results[3]. From one hand, the structure and function of multiple heterogeneous molecules is presented, and on the other hand, it contains the biggest network that is presented to students of Biology, the metabolism. Furthermore, the subject classically introduces enzyme kinetics which includes several conceptual and mathematical models that complicate the integration of the concepts.

In order to facilitate the comprehension of these ideas we proposed a methodology based on solving questions. The main idea of this methodology is proposing to students a set of short response questions that should be addressed during the course. The proposed benefit of this methodology is that students find many of the concepts that are part of the subject in an autonomous way. This lets the students acquire these concepts in an autonomous way with the supervision of the professor during personal tutorship. We hypothesize that some concepts can be better understood if let to students to deep into instead of presenting them during lectures.

2. METHODOLOGY

The study is contextualized in a course of general biochemistry in the Biology Degree of University of La Laguna. It is an obligatory subject of the first semester of the second course. Every year an average of one hundred student (117 during the course 2019-2020) register in this subject structured in a single theory group and five groups of seminar and practical lectures. The subject covers three main biochemistry topics: structural biology, enzyme kinetics and molecular biology. During the second semester another subject includes the metabolism. The contents are split into twelve topics, five for structural biology, four for enzyme kinetics and three for molecular biology.

Each topic is presented in a single session of two hours. The first hours is a lecture of many of the concepts of the topic and during the following hours a set of between six to ten questions are presented to be solved in groups of four or five students under the supervision of the professor. One important thing is that the professor never reveals the answer during

ISBN 978-84-09-22254-4

these sessions, but instead he points out some references to keep looking for. Students know that they have to get the answers for all the questions during the course. Assistance in tutorship is possible but, again, the professor does not give any answer.

At two specific moments of the course the students make two exams about these questions. The exams are made individually in a room supervised by the professor without access to any information. In order to guarantee that students know the right answers one or two days before each exam a session for checking the answers is organized. In this session the professor validates the correct answers given by the students to the questions releasing only the questions that become unsolved by any group (a situation that does not happen in practice with any question). After these two exams the professor can be sure that these concepts that were not explained in lectures were searched and studied on their own. 103 of the 117 registered students followed these approach of preparing the questions and doing the two exams of the questions.

At the end of the course there is a final exam that covers all the theory, including the concept that were part of the questions and that were not presented in lectures. The exam consists of 40 type-test questions (in this study one of the questions was removed from the analysis for being wrongly written) with four options and only one of them is correct. Some of the questions that appear (31 questions referred as *lecture*) are questions of concepts presented in lectures by the professor and some others (8 questions referred as *autonomous*) cover concepts that were prepared in an autonomous way by students. After this final exam students have up to three more dates to take the exam, some of the many months after the end of the course. In order to consider those students that retain the best the information from the autonomous work only the first exam will be included in the analysis, which is the closest in time to these sessions. 41 students did the first final exam and all of them participated in the question solving autonomous session. Integrating all the questions of the exam we got a total of 1599 exam questions, being 1271 *lecture* questions and 328 *autonomous* questions.

A Chi squared test was be performed into a contingency table in order to find potential significant differences in the right and wrong number of answers between the *lecture* and the *autonomous* questions. We assumed a significance of 0.05 to discriminate the p-value.

3. RESULTS AND DISCUSSION

The final exam of biochemistry in this degree traditionally presents a passing rate of around 60 %. In the first final exam of the course 2019-2020 from the total of 41 students that did the exam 26 of them got more than 5 out of 10 points (63 %). This data stays around the expected value of previous years. Higher marks were not expected because the number of *autonomous* questions in the exam was low (8 out of 39).

Concerning to the number of right and wrong answers in the *autonomous* and *lecture* questions, the following table and figure contain the results obtained by the students in the first final exam.

Categories	Right	Wrong	Total	Questions	Students
Lecture	606	665	1271	31	
Autonomous	189	139	328	8	41
Total	795	804	1599	39	

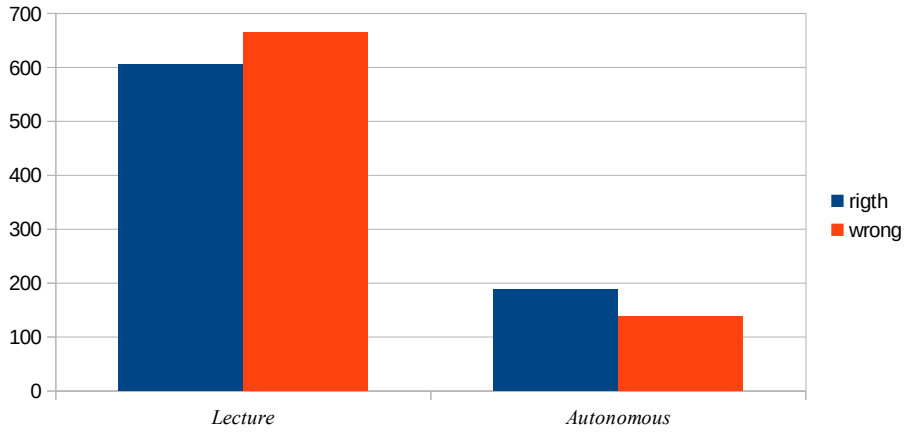

Figure 1. Results of the final exam split by the type of question.

ISBN 978-84-09-22254-4

It can be seen that the number of right answers is higher that the wrong answers in the group of autonomous questions. This pattern, if statistically confirmed, would provide evidence that the students got better understanding of the concepts that were prepared in an autonomous way in contrast with the ones that were presented by the professor during the lectures. Because the final exam questions were formulated in a different way from the ones made in the two exams made during the course we can discard that the students memorized these questions for the final exam.

The following table shows the expected values to perform the Chi square test.

Categories	Right	Wrong
Lecture	631,92	639,08
Autonomous	163,08	164,92
Chi squared		10,31
P-value		$1{,}32 \cdot 10^{-3}$

The Chi square analysis provide a p-value of $1{,}32 \cdot 10^{-3}$ which fall far below the significance established. This analysis validates the pattern observed in figure 1. Confirming that students got significant better responses in the questions prepared by themselves.

These results are relevant because they support the thesis of active learning. In addition to the objective results during the course it was clear by the professors that the students got a deep comprehension of the concepts behind the autonomous questions. It was manifested during the tutorship sessions in which the professors found out how students were showing doubts about deeper concepts as long as the course advanced. In some cases, even the professors had to refresh very complex concepts that the students found during the search to be able to help them appropriately.

Also the perception of learning by the students was positive. In figure 2 it is shown the answer of 59 to an anonymous survey in which we asked them to say if they considered they learned more (yellow), the same (red) or less (blue) than in other subjects of their course. This question is relevant because the other subjects are lecture-centered.

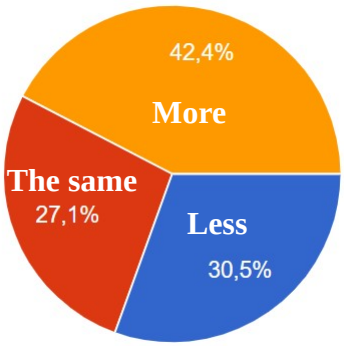

Figure 2. Answers to an anonymous survey for the students for the questions: “did you consider you have learned more than in the other subjects of your course?” In yellow “more”, in red “the same” and in blue “less”.

More than half of the students considered that they learned at least the same than in other subjects. This is important because this subject contains a significant less amount of lectures (half of the theory of the subject compared with other presenting close to 100 %). This shows that having less lectures does not produce a feeling of “learning less” in the majority of students.

It is important to highlight the fact that the evaluation of the subject was not the proper way to evaluate an active learning methodology. A type-test exam only requires memory for the students to get good marks which can hide other important competences of the students acquired by active learning. Even under this situation, this module demonstrates to help the memory-based acquisition of concepts. We explain this because many of the concepts that were asked in the final exam were learned by heart after working with them during the process of looking for the answers.

ISBN 978-84-09-22254-4

These results together with the distribution of right and wrong answers in the *autonomous* and *lecture* questions in the final exam validates this methodology based on autonomous question solving in a higher education course of biochemistry. Given that most of the courses in higher education are lecture-based any move towards the direction of active learning is going to improve the efficiency of the learning process of students.

4. CONCLUSIONS

Here we showed an active learning-based module applied to a theory course of biochemistry in higher education. The module used the methodology based on autonomous question solving which covers part of the concepts that were not presented in the lectures. The results of the study show that the questions that covered concepts prepared in an autonomous way by the students were answered right in a significant higher rate than the question related to the lectures. Also, the perception of learning was at least as good as in other subjects that were lecture-centered.

5. REFERENCES

[1] Michael, J. "Where's the evidence that active learning works?" *Advances in Physiology Education,* 30(4):159-67 (2006).
[2] Wright, G.B. "Student-Centered Learning in Higher Education" *International Journal of Teaching and Learning in Higher Education*, v23 n1 p92-97 (2011).
[3] Santos, G. and Torres, N.V. A simple simulator to teach enzyme kinetics dynamics. Application in a problem-solving exercise. *Higher Education Pedagogies*. 2(1): 14-27 (2017).

 ISBN 978-84-09-22254-4