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Learning about Krebs and his Four Metabolic Cycles by Using a Problem-Based Learning Approach

Miguel Ángel Medina Torres[1], Ángel Luis García-Ponce[2], Ángel Blanco-López[2], Ana Rodríguez Quesada[1], José Luis Urdiales[1], Ignacio Fajardo[1], Fernanda Suárez[1], Francisco José Alonso Carrión[1]

[1]Universidad de Málaga, Andalucía Tech, Departamento de Biología Molecular y Bioquímica, Facultad de Ciencias, Málaga (Spain)
[2]Universidad de Málaga, Andalucía Tech, Departamento de Didáctica de la Matemática, de las Ciencias Sociales y de las Ciencias Experimentales, Facultad de Ciencias de la Educación, Málaga (Spain)

Abstract

In the context of an Educative Innovation Project (EIP) to be developed in the academic curses 2019-20 and 2020-21 and entitled "Collaborative learning of Biochemistry based on projects and case and problem solving" and two other previous EIP, we have designed and used problem-based learning (PBL) cases to help our students to study metabolism and tis regulation. One of these PBL cases was focused on the four metabolic cycles described by the Nobel prize winner Sir Hans Krebs. In two subjects dedicated to the study of metabolism regulation, one from the Biology Degree and the other from the Biochemistry Degree, we recruited volunteers to work in groups and collaboratively to solve the PBL cases. The final grades in the global evaluation of the students who participated in this activity were notably better than those who did not. In the present communication, this experience is analyzed and discussed. This work is supported by an Educative Innovation Project (PIE19-057, funded by University of Málaga).

Keywords: collaborative learning, Krebs, metabolism

1. Introduction

Biochemistry is considered to be a very demanding and difficult discipline for science students. Within the contents of a general biochemistry, metabolism, its regulation and integration is one of the most complex topics of study for students, due to its broad contents and the need of integrate them in a biologically meaningful manner [1-4]. We have incorporated collaborative and flipped learning strategies to make our students key players in their own learning process [5-13]. It has been claimed that collaborative learning strategies helps students to study biochemistry and metabolism [14-17]. The use of problem-based learning (PBL) has been of paramount importance in order to achieve this aim [4,13,18-20].

2. Design and contents of the PBL devoted to the four cycles described by Krebs

The whole activity was designed within the framework of a design-based research methodology [21] and applying a teaching learning sequence (TLS) [22] focused of a PBL devoted to the four cycles described by Sir Hans Krebs [23,24]. The same TLS can be applied for PBLs devoted to different metabolic contents, as illustrated by the flow chart of the TLS adopted by us in the case of another PBL devoted to glycogen metabolism [see figure 1 in 25]. At the beginning of the TLS the PBL should be designed and its contents selected. In the present case, we decided to prepare a set of activities helping the students to learn the four metabolic cycles described by Krebs, their regulation and their integration with other metabolic pathways. The critical role of Sir Hans Krebs in the elucidation of the urea cycle and the tricarboxylic acid cycle is well known and usually well described in general biochemistry textbooks [26-28]. However, it is much less known that Krebs also had a key role in the initial description of other two metabolic cycles, namely, the glyoxylate cycle and the uric acid cycle [23,24,26-29].

The "four Krebs' cycles" PBL included 46 guided tasks organized around four topics, as follows: (1) Historical aspects of the scientific studies of Sir Hans Krebs, six tasks. (2) On the structure and properties of some molecules involved in the Krebs' cycles and the topology of theses cycles, 10 tasks. (3) The Krebs' cycles, their regulation and metabolic integration, 21 tasks. (4) Diseases linked to a misfunctioning of the cycles described by Krebs with biochemical foundations of selected clinical cases, 9 tasks.

A relevant part of these tasks was selected from known and prestigious textbooks and student's guides on biochemistry [26-29] as well as cases and patient profile cases contained in the instructor's resources of Voet and Voet Biochemistry [26] and Marks' *Basic Medical Biochemistry* [30]. Additionally, some tasks focused on pedagogical resources elaborated by students of our courses on metabolism enrolled in previous academic years, as well as on selected original and review scientific articles and the exploitation of useful online resources, including biological databases. In all the cases, the guided tasks were designed to stimulate critical thinking and cooperation, rather than competition. Once designed and prepared the whole PBL, the complete set of activities was properly presented to all the students of the courses from which volunteers were later recruited.

3. Recruitment of volunteers and implementation of the tasks in a model of collaborative learning and flipped class

At our Faculty of Sciences (University of Málaga, Spain), metabolism is a topic covered in three mandatory courses (one in the second academic year of the Degree in Biochemistry, another one in the second academic year of the Degree in Biology and the third one in the third academic year of the Degree in Chemistry), which are mainly devoted to the study of metabolism, its regulation and its integration. For the present educational experience, we recruited volunteer students among those enrolled in the first two mentioned mandatory courses at the beginning of the second semester of the academic year 2018-19. Volunteer students signed a learning contract [12] and were split in groups of 3-4 components. Afterword, the PBL contents were presented and commented to all the groups, which started to work autonomously to solve the whole PBL on their own for the following two months. During this time of autonomous work, groups could demand tutoring from their professors any time they felt they need it. At the end of this period of time, each group had to present a report with the detailed answered to all the tasks of the PBL and the solutions provided by the different groups were contrasted and shared in a public session at the classroom.

4. Educational results

To evaluate the impact of this PBL activity on the learning process, three kinds of analysis were implemented: (1) all the enrolled students (volunteers that had signed the teaching contract and those that had not) anonymously answered the questions of a test on their knowledge regarding Krebs' scientific work and the metabolic cycles described by him both at the beginning and at the end of the semester; (2) the reports from every involved volunteer group were analyzed and evaluated; and (3) scores of volunteers and students not involved in the learning contract in the final exams were compared.

The increase in the percentages of correct answers in the post-test as compared with the pre-test was greater among the volunteers than among the students that did not signed the learning contract. Furthermore, global scores were remarkably better for those volunteer students that had signed the learning contract rather than for those who did not. Most of the volunteers declared that they felt that this PBL approach has been useful for them, believed that they had learned more, but that they also have worked more and harder than for the resolution of other kinds of tasks. Overall, around a 80% of students enrolled in this study declared to be "very satisfied" or "satisfied" with their experience.

5. References

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