Advances in the Use of the Model of Flipped Classroom with Collaborative Learning as a Helpful Tool to Study Metabolism

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Abstract

The transition from the traditional educational model centered on teaching to that emanating from the EHEA focused on learning and the acquisition of competences by the student implies a change in the educational paradigm. This makes it necessary to complement the master classes with active methodologies that enhance the central role of the student in his or her learning process. Our experience shows that collaborative learning and class inversion (flipped learning) are methodologies that can be useful to improve the teaching/learning of Biochemistry and metabolism for Biology student. However, because of the idea that they will be forced to give up parts of the curriculum, not many teachers use it in the teaching of Biochemistry. The different roles of teachers and students in this new scenario, its advantages and disadvantages, flipped learning, collaborative learning and problem-based learning are analyzed in the present communication with specific hints to their application for the learning-teaching of metabolism.

Keywords: *collaborative learning, flipped learning, metabolism*

1. Flipped learning

The European Higher Education Area (EHEA) has changed the focus and the models of learning-teaching from traditional educational models centered on teaching to a learning-teaching model centered on the students as the main protagonists of their own learning through the acquisition of competences. In this new scenario, the role of teachers and professors changes to that of an accompanying facilitator of the learning and acquisition of competences by their students.

The term "flipped learning" encompasses a set of teaching methodologies that have the following points in common: a) The information to be learned by the student is taken out of the classroom and transmitted by the teacher online as links to documents, presentations, videos and podcasts, etc. b) Class time, instead of the traditional master classes, is dedicated to discussing what the students have not understood well, working on cases, projects and problems, collaborative work, etc. (active and inductive learning). All this takes place under the supervision and guidance of the teacher.

The different methods of flipped learning differ, fundamentally, in the type of online communication before classes; in the way in which it encourages and checks the student's previous study, and in the tasks or specific activities that are carried out in the classes. With these methodologies, not only the use of time and space in the classroom and outside is reversed, but also the role of teachers and students in the classroom is altered. In traditional classes the teacher is the protagonist, he or she is placed on the stand looking at the students and explains the lesson while they attend, take notes and occasionally ask questions. In reverse teaching, on the other hand, the students are the main protagonists, they work actively while the teacher observes how they do it, helping them when they have problems or when they are asked to do so.

Flipped learning can be much more pedagogically effective learning methodology than traditional master classes. Some of its strengths are: a) It stimulates the students' continuous study, avoiding the typical last minute binges. b) It makes it easier for all students to understand the information, since they can access it as many times as they want. c) It allows class time to be spent on activities led by the students without slowing down the pace of progress with the syllabus, since it is transmitted online. d) It allows the realization of formative evaluation activities and metacognitive reflection during class time. e) The tasks are done and corrected during the class, thus facilitating the management of the teacher's feedback on the work products of their students. The main weakness of the inverse model is that it gives more work to teachers, especially: a) In the preparation and design of the materials to be transmitted to their students. b) In the preparation of pre-study verification questionnaires, and the

analysis of the students' answers. c) In the redesign of classes to respond to difficulties and to carry out new activities.
The first well-documented model of a flipped classroom was carried out in 2007 by the chemistry teachers of Woodland Park High School in Colorado (USA), Aaron Sams and Jonathan Bergman [1]. The used simple software that allowed them to capture images of the power-point presentations of their classes, began to record videos so that those students who had not been able to attend the presentations would have the opportunity to retrieve them. After some time, they noticed that even those students who regularly attended the classes consulted the videos and used them to prepare for the exams. It was then that they thought that if they sent the students to watch the videos as homework and take notes of their contents, they would be able to spend the time in class solving doubts, discussing and carrying out other activities where the students would apply what they had learned. Later, due to the positive results they obtained with their students, they decided to freely share all their class videos as open educative resources. Before that date, methods had been developed to check the previous study of the students using reverse methodology, although they did not use videos to transmit the information to the students (YouTube did not exist), but different electronic documents. Of these methods (known as blended-learning methods) the Peer Instruction, the Just-in-Time-Teaching, and the Team Based Learning stand out [2-4]. Currently, there are many combined flipped learning methodologies [5,6]. One of the most widespread methodologies, and the only one that will be discussed here, is the Flipped-classroom with Just-in-Time-Teaching (JITT-FC). To implement this method, a few days before the start of the class, the teacher indicates to his students what documents of the virtual campus they should study (links to videos, electronic documents, etc.) and send them a questionnaire that they should return at the end of their study. From the analysis of the answers to this questionnaire the teacher will obtain valuable information about the level of understanding of his students, the parts of the subject that they understand well, and therefore it would not be necessary to influence them in class, and those in which they find special difficulties or make mistakes. This information will allow the teacher to rethink his or her class and guide it ad hoc in order to clarify precisely these points of conflict. If, after these clarifications, time is left over, the rest of the class could be dedicated to activities where students can actively apply what they have learned, discuss, solve problems in groups, etc. This type of approach allows two important things to be combined: on the one hand, to be able to advance in the program without losing time, and on the other hand, for students to work actively and do exercises that help them to increase their understanding under the supervision of the teacher.
The interest in flipped-learning methodologies is growing day by day, as indicated by the almost 30,000 educators from all over the world already registered at the Flipped Learning Community Network. In the specific case of Biochemistry and Metabolism, the work done by Professor Brent Stockwell is especially noteworthy. Since he joined the Columbia Center for New Media Teaching and Learning (CCNMTL) in the summer of 2013, he has been teaching Biochemistry with inverted class methodology.

2. Collaborative learning

Collaborative learning is grounded on social constructivism, which considers learning a social process that is built not only with the teacher, but also with peers, the context and meaning of what is learned. This learning approach not only favors the academic performance of students but also allows them to acquire important transversal competences that are very useful in their professional development. An efficient collaborative learning approach is characterized by the following five features [7]: a) Positive interdependence. b) Individual and group accountability, to avoid free-rider effects [8]. c) Promotive interactions. d) Appropriate use of social skills. e) Group processing, with critical self-evaluation of the work carried out within the group. In the specific case of the learning-teaching of Biochemistry, the opinion of teachers and students in relation to the implementation of collaborative learning methodologies is, in general, very positive [9-13]. Having said all this, it should be noted that collaborative learning is an appropriate method to achieve certain skills, achievements or goals, but it does not work for everything (and not everyone is well adapted to this way of working). Thus, there are situations in life where we are forced to compete with others; for example, when we apply for an interview to get a job, or when we are looking for the best mark in a competition to get a position. Having clear ideas and demonstrating autonomy in the use of specific skills are factors that, depending on the circumstances, can also be highly valued in the field of work. Therefore, in reality, all students should be taught to acquire individualistic, competitive and collaborative skills in a balanced way. In this sense, too, collaborative learning cannot be seen as a substitute for lectures or other traditional methods of classroom interaction but, as even its most ardent proponents believe, a useful complement. However, effective collaborative learning application demands new skills and more effort from the teacher than giving master classes. Furthermore, many teachers find it difficult to use this model of collaborative learning without affecting the projected syllabus for their subjects. These problems could be alleviated by associating the collaborative learning with methodologies that, like those of flipped learning, allow "gaining time" without sacrificing content.

3. Problem-based learning

The first uses of problem-based learning (PBL) date back to the 1960s, when the faculty of McMaster University in Canada observed the lack of health problem-solving skills of their graduate students, despite the extensive knowledge they had acquired throughout their curricular studies [14]. PBL thus emerges as an alternative methodology, which emphasizes that students take a more active part in their learning process, with the teacher playing a mere "facilitator" role. From the beginning, defining exactly what PBL means has been a difficult and sometimes controversial task, which even led one of the greatest specialists in this educational strategy, Howard S. Barrows, to carry out a taxonomic study on the types of PBL that would help to clarify the different uses and objectives of this then novel and innovative educational strategy [14]. A decade later, Gallagher et al. [15] set the parameters that, in their opinion, an education strategy based on PBL should have: (i) start by establishing a complex or insufficiently structured problem; (ii) use the problem as an element to organize the learning agenda; and, (iii) the role of the teacher as a meta-cognitive tutor. This is one of the first contributions that defines what the teacher's framework of action should be as a guide rather than a source of knowledge. Two of the first in-depth literature reviews on PBL should be underlined [16,17]. Although the PBL approaches had their origin and greatest development in the area of health science [18], they have been extended to other natural and social sciences [19,20]. PBL can be used as a powerful strategy of collaborative learning. However, the lack of a sufficient number of cases or projects to be applied to teaching by means of this tool is a fact, accentuated in the case of one of the most complex topics of study for the student of Biochemistry such as the regulation of the metabolism and its integration [21]. This encourages not only collaboration in increasing the scarce teaching resources available to the educational community, but also the application of some of the guidelines of educational research focused on design with implementation and evaluation to be carried out with university science students, through case studies [21-25].

4. Our experience of collaborative learning and class inversion to study metabolism with the aid of PBL

Biochemistry (and, in particular, metabolic regulation) is perceived by students as a very demanding and difficult discipline [26]. This means that many students show a certain detachment that translates into a delay in facing their study, even in some cases to temporary abandonment of it. In addition, the first approach to the study of Biochemistry by a large number of university students is superficial [27]. This phenomenon, which has been relatively studied in some countries and referred to mainly in the Anglo-Saxon specialized literature [28,29], does not seem to have a more local counterpart in terms of its problems in Spanish universities. In spite of the periodic meetings held by specialists in the workshops on Biochemistry Teaching, organized by the Spanish Society of Biochemistry and Molecular Biology (SEBBM), there are almost no relevant studies published on the nature and scope of this learning difficulty. On the other hand, the almost always exclusively "scientific" training of this teaching staff, with a pedagogical training exclusively fed by years of practice, marks the bias of the development of the designed and applied teaching tools, without making the approach and rigour that quality educational research requires and without a real evaluation of their scientific impact [30].
The use of PBL for the learning-teaching of biochemistry is still very restricted in comparison to the classical teaching of this subject, judging by the limited bibliography that can be found on the subject [31]. Furthermore, this strategy has been distorted over time, leading to a simple case study approach [32]. Some authors believe that its poor implementation is compromised mainly by the lack of conviction of teachers and institutions, the poor supervision and evaluation of the specific curriculum for PBL, as well as by the lack of confidence in the knowledge that students acquire or the motivation of educators, thus hindering the great potential that this educational strategy can have [33]. In spite of these problems and limitations, we are confident that the preparation of new problems or cases on regulation of the metabolism could help to achieve one of the teaching objectives most desired by teachers of this discipline, which is a more integrated vision of the knowledge that their students acquire throughout the course [21,34].

5. Some preliminary results

If Biochemistry is a very demanding and difficult discipline for science students, learning about the metabolism, its regulation and integration is one of the most complex topics of study for biochemistry students [35]. Since years ago, we are using collaborative and flipped learning strategies to increase the role of our students in the process of their own learning [36]. To achieve this aim, our use of PBL has been essential [37]. Flipped learning application leaved us time to introduce both virtual and face-to-face collaborative tasks. These tasks were carefully designed as to boost co-operative attitudes among students, and they fulfilled the five essential requirements for an efficient co-operative learning mentioned above [7]. We used the framework of a learning contract, which revealed to be a very efficient tool to increase our students loyalty to the subject (and hence to increase their attendance to exams). The flow chart of our use of PBL for the collaborative learning-teaching of metabolism has been previously published [37]. Enrolled volunteer students of our two courses on "Regulation of Metabolism" (Grade of Biochemistry) and "Metabolic Regulation" (Grade of Biology) were organized in groups of 3-4 students. All the groups received a document containing a set of instructions and rules to solve the "case", along with all the tasks included the case. Each group could freely decide how to share the tasks and to organize the complete work of the group. Groups were allowed to work around the case for two months. During this period of work, groups were allowed to demand tutorial sessions and guidance from their professors. At the end of this working time, each group should prepare a final report clearly describing the response provided to each task. In the final report, members of each group should add a public declaration of engagement, with mention of the specific work carried out by each member of the group in the resolution of the overall case. Up to now, we have developed extended PBL cases to guide our students' self-learning of important blocks of the contents of a Metabolic Biochemistry such as the regulation of glycogen metabolism, the four Krebs cycles and OXPHOS. In the moment in which this contribution was written, the COVID-19 outbreak had produced in our University, as in many others around the world, a transitory change from face-to-face classroom classes to a 100% virtual teaching. Under these conditions, the previous implementation of flipped learning, collaborative learning and PBL in our Metabolic Regulation courses has greatly contributed to a softer transition, which has been welcomed by our students.

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