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A step-based learning methodology applied to veterinary science students in biochemistry classes

Una metodología de enseñanza basada en pasos y aplicada a estudiantes de ciencias veterinarias en clases de bioquímica

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Abstract

In an attempt to improve engagement and performance of first year veterinary science students in biochemistry issues, we applied a teaching strategy as follows: the subject was separated into four steps breaking down each one of the topics. Each step was a prerequisite for the next one and at the end of a step, the students had to answer questions and discuss the studied step enabling them to go on to the next step or review. In this way, knowledge was built throughout the classes and both students and the professor were able to point out some misunderstandings, knowledge deficiencies, and pedagogic problems, solving these class issues more effectively. In the work, we focused on studying Enzymes, an interdisciplinary subject that involves thermodynamic and kinetic concepts applied to a biological context. According to the students, they were able to define their learning deficiencies more specifically and become more committed to the class. Additionally, this teaching strategy was clearly effective in maximizing the progress of students.

Key words: *biochemistry, teaching methodology, veterinary science students*

Resumen

En un intento de mejorar la participación y el rendimiento de los estudiantes de primer año de ciencias veterinarias en bioquímica, hemos aplicado una estrategia de enseñanza de la siguiente manera: el asunto se separó en cuatro pasos para descomponer cada uno de los temas. Cada paso era un requisito previo para el siguiente y al final de una etapa, los estudiantes tenían que responder preguntas y discutir el paso estudiado lo que les permite pasar a la siguiente etapa o revisión. De esta manera, el conocimiento se construye a través de las clases y los estudiantes y el profesor fueron capaces de señalar algunos malentendidos, las deficiencias de conocimientos, y los problemas pedagógicos, para resolver estas cuestiones de clase de manera más efectiva. En el trabajo, nos centramos en el estudio de enzimas, una materia interdisciplinaria que involucra la termodinámica y conceptos cinéticos aplicados a un contexto biológico. Según los estudiantes, ellos fueron capaces de definir específicamente sus deficiencias en el aprendizaje y ser más comprometido con la clase. Además, esta estrategia de enseñanza fue claramente eficaz para maximizar el progreso de los estudiantes.

Palabras clave*: bioquímica, metodología de enseñanza, estudiantes de ciencias veterinarias.*

INTRODUCTION

In veterinary education, biochemistry is highly relevant since it will enable students to study applied sciences, such as animal nutrition, physiology, and genetics (Krishnaraj, 1979). Biochemistry is taught to graduate students generally by didactic lectures in the first year. A professor is very often seen as imparting information and knowledge to students, where their role in the teaching-learning process is largely unconsidered and the information is absorbed in a passive way. However, even this way the process efficiency is deeply related to the presentation or organization of the material used for the class (Åkerlind, 2004). In addition, substantial loss of basic science knowledge and the ability to make use of it in medical school has been observed (Wilhelmsson *et al.*, 2013).

The professor finds it very difficult to teach students who are unhappy. S/he believes the subject is interesting and relevant, but the students may be less than enthusiastic due to the difficulties they face. Furthermore, they are interested in exploring and learning about modern exciting discoveries but are less keen to learn basic principles (Wood, 1990).

Students, especially entrant students, often report misconceptions and learning difficulties associated with various concepts, especially those invisible and untouchable ones (Barak and Hussein-Farraj, 2009; Mnguni, 2015).

Students learn more effectively if they are active during the learning process. Active participation can stimulate deep learning and high-level engagement (Marton and Säljö, 1976). Science courses consisting of traditional lectures and cookbook laboratory exercises need to be changed to scientific teaching, based on evidence (Handelsman *et al*., 2004). Problem-based learning in a veterinary medical education is an effective pedagogy that can often employ constructivist theory to achieve its curricular and pedagogical goals (Maza, 2013).

Our goal in this study was to describe an alternative teaching approach applied to the Biochemistry discipline of first year Veterinary Science Course students from the "Instituto Federal Catarinense" - Brazil, in an attempt to improve teaching-learning process and engagement of the students in biochemistry studies.

METHODOLOGY

The study was conducted on 54 first-year students enrolled in an introductory biochemistry course at a Brazilian public higher education institution. Enzymes were the subject used in this study, commonly covered in a chapter in classical Biochemistry textbooks. The topics related to enzyme study were organized in a knowledge gradient, separated into four steps. The first one was a conceptual step, providing a background. The next steps involved enzyme application as enzymatic reactions and how they work (step 2), enzymatic kinetic and inhibition (step 3), and examples applied to veterinary studies, including the main veterinary clinical enzymes and the units used to measure their activity (step 4).

The teaching-learning process was evaluated at the end of each step by asking students five questions. The questions involved conceptual, taught and applied knowledge. The students were also questioned about their opinion on the methodology, concerning its efficiency in learning compared to classical methodologies.

RESULTS AND DISCUSSION

In order to become enrolled in Brazilian Higher Education Institutions, students must have graduated from the secondary education level and to pass an entrance examination called "*vestibular"*. A decade ago, the Brazilian government launched ENEM (Secondary Education Evaluation Exam). Since then, some institutions accept ENEM as part of the admission process. In addition, there is a law to reserve admission slots in public universities for students who attended public primary and secondary schools and for some racial and ethnic groups.

This work was developed in the first year of the veterinary curriculum in the "Instituto Federal Catarinense", a public higher education institution, located in Santa Catarina State, in southern Brazil. However, most students do not have sufficient background in organic chemistry to be prepared for adequate learning. Low performance and apparent lack of ability have been observed in past years among most students.

Biochemistry is introduced in the first year of the veterinary curriculum and according to Nelson and COX (2008), students who face biochemistry consider two key aspects to be difficult, approaching quantitative problems and drawing on what they had learned in organic chemistry to improve their understanding of biochemistry.

According to the scope of the Biochemistry curriculum, we aim to produce not only students who are prepared with knowledge on the modern aspects of the discipline, but also to help them make connections and apply the knowledge to the needs of the veterinary professional practice.

Among the diversity of the teaching methods, the lecturer should choose the method that makes teaching more efficient, more informative, more varied and more interesting in order to achieve the goals and teaching objectives.

This work studied a way to test a learning methodology on enzyme biochemistry. In general, it is a difficult subject to learn, since it requires thermodynamics and a kinetic knowledge background for proper learning. It employed visual models, such as pictures and diagrams, due to the complex nature of the concepts.

Effective learning is a process and not an event. The subject of the class (enzymes) was presented as a menu divided into four steps (Appendix 1). The four-step methodology broke this subject down, in a rationale way, so that the students could have a general overview. It was first presented to them following a discussion on these steps. The general concepts of enzyme structures and functions, and the importance of studying how fast the enzymatic reactions take place and how these are applied to veterinary science. These concepts were discussed to help prepare students to begin their classes. The idea is to begin on the whole and expand that to individual parts. This way, students improve their mental organization on the subject and this helps them to identify what they do not understand without missing the idea of the entire subject and then, they become more confident in their learning. They become part of the process and decrease their discontentment. It has been observed and, even reported, by some students that they were satisfied because they have developed their own goals and assessments on the subject studied. On this issue, one student stated:

> *"I think the methodology of dividing the subject into steps is interesting because it defines the subject and helps the students to have an idea on the range of the subject" (Student 1).*

During the process, the professor helped students to question their preconceptions and motivated them to further their learning, by asking some questions at the end of each step. At this point, the students needed to answer about five questions on a piece of paper for the professor to gather feedback from the students, and then they were allowed to discuss with other classmates and review their notes. There were different approaches to the questions, conceptual, reasoning, and applied knowledge. Regarding step 2, as an example, students were asked to explain why activation energy is not considered in the Gibbs energy reaction ($\Delta G'^{\circ}$), as a conceptual question. This way, it was possible to review that enzymes, as catalysts, do not affect reaction equilibrium, but just increase reaction rates. As a reasoning question, we asked them why enzyme complementary to substrate model is not accepted, if part of the energy used for enzymatic rate enhancement is derived from weak interactions between the substrate and enzyme. On this question, students were able to discuss and compare the enzyme complementary to substrate and transition state models, respectively. They compared the weak interaction pattern and the relationship to activation energy in both models. Additionally, for applied knowledge questions, they needed to interpret a reaction coordinate diagram comparing enzyme-catalyzed and uncatalyzed reaction.

Concerning the questions, one student stated:

> *"This method was valid, as we were required to pay attention during the class so that we could answer the questions correctly and this helped the subject absorption" (Student 2).*

Moreover, there was another opinion given:

> *"I enjoyed this method because learning became easier. The subject was divided into steps and that helped me to understand better. The questions at the end of each step made us think about what we had just learned and identified our doubts so that we could solve them" (Student 3).*

The students' discussions were important because they tested their learning by explaining to each other and it was a way to involve all the students in a constructive discussion, even those who were quiet or apparently not interested in the class.

This way, the questions worked as refresher shots and they were part of the strategy for long-term memory retention. This habit of frequent review added to the discussion among students, which also helped in the comprehension of the topics and for self-evaluation. Furthermore, discussion among students contributes to learning and creates strategies for collaborative knowledge construction.

Additionally, note taking helps to both recall the subject of the lecture, synthesis and application of new knowledge in class or afterwards (Bligh, 2000).

Analysis of the answers clearly revealed some misunderstandings, misconceptions, basic knowledge deficiency and didactic failures. Therefore, at the beginning of each new step, the pedagogical strategies were reoriented to solve the identified learning problems, sometimes working on specific students after class. Students were encouraged to clarify their doubts in and after class, in order to progress and keep up with the rest of the class. At the beginning of the program, we highlighted the importance of self-commitment, working hard, and the challenge of achieving knowledge and overcoming learning handicaps before starting the next step in the program. This way, there was no need for any students to repeat any step and both of them progressed at the same pace in this study. It is even possible that some students who have serious basic knowledge handicaps will require extra work in order to make progress, and probably, they will progress at a different pace as compared to the rest of the class.

The questions worked as a thermometer for the professor's pedagogic skills and they helped in identifying basic concepts of deficiencies (from high school) that should be worked on or used to design the curriculum of a basic chemistry course for first year veterinary science students. At this moment, it was possible to intervene specifically on the critical points and avoided the identification of delayed learning problems and low performance. On this issue, one student stated:

> *"I believe the methodology is useful, because it tests me to verify what I understood about the subject. And it helps me to discover my doubts and this way I have time to clarify them with my professor" (Student 4).*

The subject was also worked on in two practical lab classes related to general enzyme proprieties and enzymatic kinetics. At these classes, the students followed a script and the professor conducted the class putting the theoretical concepts into practice in the laboratory; thereby creating new understanding.

The activities were evaluated by the students through written questionnaires and informal conversations, demonstrating good acceptance and approval of this method. In general, most students thought the step methodology and questions were effective and helped them to know what was more important and what they did not understand. This way, the doubts became clear enabling them to go on to the next step.

CONCLUSIONS

In conclusion, the findings presented in this paper reveal the step-based learning methodology applied to veterinary students. This helped them to have a clear understanding on individual parts of the entire subject, which they had not understood, preventing cumulative misunderstandings, low performance and missed knowledge. The methodology was also important to evaluate the didactic practices used in class. Good student scores in biochemistry exams indicated that these activities are also working as valid educational tools.

Additionally, this methodology could be part of the repertoire of pedagogical skills that are effective in meeting the developmental and learning needs of all students.

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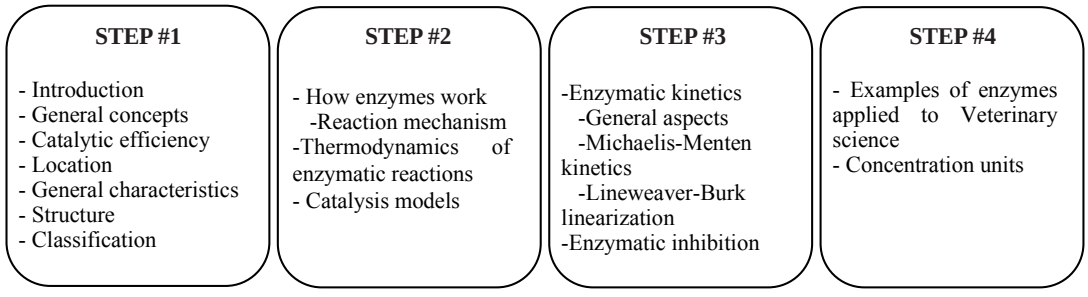
Appendix 1

Schematic representation of the class subject presented as a menu divided into four steps. Step 1, introduction of the enzymes study and some general aspects of its structure and classification; Step 2, thermodynamics of the enzyme-catalyzed reactions; Step 3, enzymatic kinetics and inhibition, and Step 4, enzymes applied to Veterinary science and concentration units.



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