New Teaching Strategies to Improve Student Performance in Fundamentals of Biotechnology†

Alicia G. Cid1 and Verónica B. Rajal1,2*

1 Facultad de Ingeniería, Universidad Nacional de Salta. INIQUI, CONICET – Universidad Nacional de Salta, Argentina; 2Fogarty International Center, University of California Davis, Davis, CA, USA 95616

INTRODUCTION

Fundamentals in Biotechnology is part of the Chemical Engineering curriculum at the National University at Salta, in northwest Argentina. This course, given for four months in the fourth year of a five-year program of study, includes concepts of general microbiology, biochemistry, and industrial microbiology and is the first contact by the students with biological issues. They arrive at this subject having an abiotic point of view of chemical engineering, and they neither know the importance of biotechnology in the industry nor the role of engineers in this science. Probably due to the long content of the course and to the lack of previous knowledge of biological and microbiological concepts, students have a lot of difficulty passing this course. Until 2007, the classes were organized into lectures (2 hours per week, optional) and practicals, of which nine were laboratories and four were problems to solve (three hours per week, mandatory), for a total of 15 weeks. About 45% of students (from a total of 30–40) passed the course, a low pass rate compared to other classes. In order to reach a better understanding of the concepts, to encourage students to learn biotechnology, and to develop critical thinking skills with the ultimate aim of improving performance, two new strategies were adopted, which consisted of including “Complementary Activities” and an “Integration Seminar.”

PROCEDURE

In 2008, one extra hour per week was added to the course for a practical class that would allow students to discuss the concepts taught in the lectures. This class, called “Complementary Activity,” included different types of work: information search, search of news in biotechnology, analysis and interpretation of figures from the scientific literature, and basic calculations, with discussion in all cases. During each class (a total of seven), a guide with the instructions was given to the students.

† Supplemental material available at http://jmbe.asm.org

In two of these classes, students were requested to search for current news about biotechnology or molecular biology, with the aim of getting students to notice the importance and the impact of these sciences in industry and in our lives. A secondary goal of this type of activity was to reinforce reading, comprehension, and synthesis capacities by identifying the main idea from a selected text and requiring the writing of a suitable summary.

Another type of complementary activity consisted of the analysis, interpretation, and discussion of figures, tables, or situations presented as results in scientific publications. In these cases, a guide was also given to the students along with four or five exercises to be solved during the class. The problems included, for example, microorganism growth curves in several conditions, antibiograms, values of oxygen transfer coefficient determined by different methods, and tables with parameters to be taken into account for a scale-up process. The students had to identify the observed behaviors, interpret the presented values, or relate and justify the produced changes.

We also asked the students, who were organized into small groups, to prepare an “Integration Seminar” that was to be presented orally to the whole class on different biologically obtained products. The students had to identify the microorganism and characteristics, the taxonomy, the biochemistry, the flow sheet of the industrial process, and the downstream requirements involved, including critical points and concerns that should be taken into account. To complete this requirement, they had to review and integrate all of the material taught during the course. They were assessed by the teachers regarding the exposition content, time, development, and their ability to express themselves.

CONCLUSION

It was observed that students were surprised when they realized the extent of important applications of biotechnology, for example, in the food industry, beverages, medicine, bioremediation, agriculture, biofuels, and nanotechnology, among others. They found really interesting news and showed a high level of attention when they talked about the different applications. The same attitude was observed in the complementary activity about molecular biology, for which they also had to look for current news about the many applications of this science (e.g., molecular diagnosis, biosensors, or immunoassays).
In the classes where students had to analyze problems and figures from scientific publications, a great deal of discussion of the different situations was achieved, and most of the students participated with ideas and questions while trying to solve the problems. In addition, we observed a better understanding of the concepts taught because the students had to use and relate to the concepts to decide the right answers for the exercises.

In the integration seminar, students incorporated all their acquired knowledge in a clear and concise exposition, which was properly presented and involved all of the issues we asked them to consider. The growth in student comprehension during the course was far more evident than in the original course format.

In 2006 and 2007, the percentages of students passing the course were 47% and 46%, respectively. After the strategies outlined here were adopted, this increased to 75% in 2008, 85% in 2009, and to 70% in 2010, with a remarkable improvement in the grades obtained. A non-quantifiable result also observed was a significant change of attitude. The students showed more commitment and a remarkable motivation to learn biotechnology, as reflected in the more frequent use of office hours to obtain additional information and to answer questions, a great interest in the discussion of ideas and interaction in class as a way of sharing and re-inforcing knowledge, and an increased interest in reading. The results obtained from this experience are promising and inspire us to continue with these strategies, not only to improve student performance, but also to show students the unprecedented development occurring in the field and the great importance of biotechnology in our lives.

SUPPLEMENTAL MATERIALS

Appendix 1: Complementary Activity - Information Search
Appendix 2: Complementary Activity - Exercises

ACKNOWLEDGMENTS

Verónica Rajal would like to thank the ASM-UNESCO Leadership Grant for International Educators from American Society for Microbiology (USA) and UNESCO, received in May 2009. The authors would also like to thank Dr. Jerold Last, from the University of California in Davis, US, for his kind help correcting the English of the manuscript. Source of support for the work presented in this article: Facultad de Ingeniería, Universidad Nacional de Salta. There is no potential conflict of interest with the work presented in this manuscript.