

Learning and teaching molecular genetics in Teacher-Led Outreach Laboratories (TLOL)

Thesis for the degree DOCTOR OF PHILOSOPHY

Submitted to the Scientific Council of the Weizmann Institute of Science

Rehovot, Israel

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2010

Abstract

The importance of molecular genetics education in Israel has been recognized in the syllabi for high school biology and biotechnology majors (11th-12th grades). Learning of molecular genetics is challenging and students have difficulties in acquiring a coherent cognitive mental model of abstract concepts such as DNA, bacteria and enzyme. This often leads to the creation of misconceptions and incorrect mental models. Biology and biotechnology teachers have a crucial role in increasing the understanding of new concepts and techniques in molecular genetics. However, it can be observed that the teachers themselves have difficulties in explaining satisfactorily some of the new technologies and methods. This may stem from the fact that molecular genetics is a relatively new field of science that moves forward very quickly and it is difficult for the teachers to maintain updated with the new information and with the modern techniques.

One of the ways to overcome those difficulties is to conduct hands-on laboratory activities. I developed hands-on laboratory activities, through which students and teachers can experience experiments in molecular genetics. In contrast to most outreach laboratories, in which the academic personnel teaches the visiting classes, the laboratory activities I developed are conducted in a unique framework, entitled Teacher-Led Outreach Laboratories (TLOL). In this framework the biology teachers themselves teach their own students at the Davidson Institute of Science Education laboratories, following an appropriate professional training. One of the laboratory activities I developed in the framework of TLOL focuses on DNA manipulations while linking between gene and phenotype. The purpose of my study is to explore the outcomes of laboratory experiments in molecular genetics, carried out in the framework of TLOL at both the high-school students' and teachers' levels. Using students' written questionnaires, aiming to probe students' mental

models and conceptual understanding of molecular genetics, I was able to show that the students' mental models of DNA and bacteria significantly improved following the activity as well as their procedural understanding with regards to DNA manipulations. Students' interviews revealed that students' comprehension of molecular genetics was retained a few weeks following the activity. In order to test whether the TLOL setting is intrinsically advantageous to the more common Scientist-Led Outreach Laboratories (SLOL) in overcoming students' comprehension difficulties in molecular genetics, a second version of the students' questionnaire was handed to SLOL and TLOL students before and following each activity. Both groups significantly improved their procedural understanding following the activities, but the TLOL group showed significantly higher understanding regarding the mental models of DNA and bacteria. In addition, I explored the relationships between students' motivation, attitudes and interest in science and their socioeconomic backgrounds, using questionnaires and semi-structured interviews. The results revealed that students from a low-socioeconomic background are highly motivated to learn science and to pursue a career in science. On the other hand, students from a high-socioeconomic background seem not to have motivation to learn science. Qualitative methodological approaches were used to probe teachers' professional development in TLOL. The analysis indicated that the TLOL setting provides the biology teachers' with professional development experiences both in terms of their Pedagogical Content Knowledge (PCK) and their Content Knowledge (CK). The experiences contribute to the biology teachers' better understanding of the subject matter and to the way they instruct this topic.

The TLOL molecular genetics activities, which are carried out in an authentic scientific setting, provide both students and teachers opportunities to participate in hands-on inquiry-based activities in molecular genetics. Therefore, on the one hand this setting enables to empower the students' with a better understanding of molecular genetics methods and concepts, and to professionally develop the biology and biotechnology teachers, on the other hand.