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Learning Biology Through Research Papers: Developing Scientific Literacy and Question-Asking Capabilities

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Biology education, like education in any other discipline, strives to make biology students familiar with the knowledge, activities, and ways of thinking of the community of biologists, and help them become biologically literate. A major component of scientific literacy is the ability to communicate scientific ideas and persuade others of their veracity. It is therefore acceptable to maintain that the reading and comprehension of scientific texts is an important component of scientific literacy.

High-school students deal mostly with texts obtained from textbooks, popular research news from the media, and review articles from popular journals. These types of texts contain descriptions of scientific research performed by scientists who are usually not the authors, and are therefore termed secondary literature. However, primary literature, can have many benefits as a means of teaching a subject matter and developing scientific literacy. Primary literature not only closes the gap between public knowledge and the frontiers of scientific inquiry, it may also instruct students on the nature of scientific reasoning.

With this rationale in mind, we developed curricula based on primary literature for senior high-school biology majors in Israel. Here we attempt to present the research and development facets of our work, with respect to the usage of research articles for learning biology in high-schools in Israel.

Learning biology using research articles

We have focused a developmental biology curriculum for high-school biology majors on three key articles in the field. The articles are presented to the students in a format of scientific research articles, which were processed especially for the program. Each article has an internal structure of a scientific article and presents a key question, the means which were taken to address this question,

the conclusions and the new questions which were formulated following the specific research. Because knowledge in developmental biology among high-school biology students is rudimentary, we have organized the articles around a central axis, which presents the basic principles of embryonic development and the open questions in the field. Using the same format, we have recently developed a curriculum in biotechnology for high-school biology majors. In addition, we have developed a web-based learning material in bioinformatics, which is based on a research article. This learning material includes interactive problem-solving activities that are based on the human-genome databases and search engines.

Research articles stimulate question-asking

Since a scientific article poses a research question, demonstrates the events which led to the answer and poses new questions, we attempted to examine the effect of studying through research papers on students' ability to pose questions. Students were asked before, during and after instruction using research articles in developmental biology, what they found interesting to know about embryonic development. Questions were scored according to three categories: properties, comparisons, and causal relationships. We found that before learning through research articles, students tend to ask only questions of the properties category. In contrast, students tend to pose questions that reveal a higher level of thinking and uniqueness during and following instruction with research papers. This change was not observed during and following instruction with a textbook.

Text genre as a factor in the formation of scientific literacy

Since reading research articles is a difficult task

for novices, we examined the possible benefits of learning using primary literature versus secondary literature, particularly with respect to their influence on the creation and formation of scientific literacy. We compared between four groups of high-school students, each with differing degrees of prior knowledge in biology, who read a domain-related text written in either the scientific research article genre (primary literature) or the popular-scientific genre (secondary literature). Although there was no significant difference in the students' ability to summarize the main ideas of each text, indicating that there was no eminent distinction in their content, we found that students who read adapted primary literature demonstrated better inquiry skills, whereas secondary literature readers comprehended the text better (Figure 1). Since the scientific content of the two texts was essentially identical, we suggest that the differences in students' performances stem from the structure of the text, dictated by its genre.

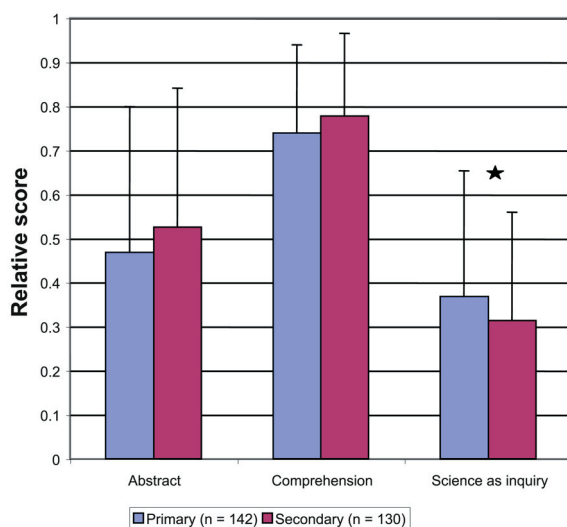


Fig. 1 Comparison between learning through a scientific research article and a popular-science article in the 10th-12th grades: 272 high-school biology students were tested for their ability to write an abstract (Abstract), their reading comprehension (Comprehension) and their inquiry skills (Science as inquiry), after reading a scientific research article (Primary) or a popular-science article (Secondary). Significant differences are marked: * $p \leq 0.05$. The data was analyzed using a *t*-test.

Selected Publications

- Yarden, A., Brill, G. and Falk, H. (2001) Primary literature as a basis for a high-school biology curriculum. *Journal of Biological Education* 35, 190-195.
- Yarden, A. and Yarden, O. (2002). Working as a team: preparing a problem awareness file. *Journal of College Science Teaching*, 32(2), 114-119.
- Brill, G., Falk, H. and Yarden, A. (2003) Teachers' journal club: bridging between the dynamics of biological discoveries and the biology teachers. *Journal of Biological Education*, 37(4), 168-170.
- Brill, G. and Yarden, A. (2003) Learning biology through research papers: a stimulus for question-asking by high-school students. *Cell Biology Education*, 2(4), 266-274.
- Brill, G., Falk, H. and Yarden, A. (2004) The learning processes of two high-school biology students when reading primary literature. *International Journal of Science Education*, 26(4), 497-512.

Selected Learning Materials (in Hebrew)

- Yarden, A. and Brill, G. (1999) The secrets of embryonic development: study through research. (A student text, grades 10-12, 2nd edition 2000, 3rd edition 2001, 4th edition 2004).
- Yarden, A., Brill, G., Levine, N., Hadad, S. and Guy, H. (2001). A Close Look at the Living Cell: A Computerized Learning Environment (developed in collaboration and distributed by the Center for Educational Technology, Tel Aviv, grades 7-12).
- Gelbart, H. and Yarden, A. (2001) Bioinformatics: decipher the secrets of the genome. (<http://bioportal.weizmann.ac.il/>, grades 11-12).
- Avrahami, M., Eran-Zoran, Y., Mizrahi, E., Piontkovitz, Y. and Yarden, A. (2003). To the cell and back: learning activities for teaching the living cell topic as a longitudinal axis. (A teacher's portfolio and students' booklets, grades 7-9).
- Falk, H., Brill, G. and Yarden, A. (2003). The secrets of embryonic development: study through research. (A teacher guide, grades 10-12).
- Falk, H., Piontkovitz, Y., Brill, G., Baram, A. and Yarden, A. (2003). Gene tamers: studying biotechnology through research. (A student text, grades 10-12).

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