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Students' interests and scientific knowledge: Making ends meet

"The trouble with school science is that it provides uninteresting answers to questions we have never asked" (a Swedish student, Osborne 2006)

The Glenn report Before it's too late states that "we are failing to capture the interest of youth for scientific and mathematical ideas." Indeed, many students find standard science curricula largely out of touch with their personal interests, a factor which contributes to the low number of students pursuing advanced science and mathematics courses in high school, and going on to choose scientific careers. Our group attempts to identify students' scientific interests and harness those interests to make biology curricula appealing and motivating to the students. Another emphasis of our work stems from the fact that biology is one of the most dynamic research fields within the natural sciences and that the gap between the accumulated knowledge in biology and the knowledge that is taught in schools increases rapidly with time. Taken together, our group's major objective is to identify means of bringing both interesting as well as contemporary biology into high-schools. Members of our group are involved in all the facets required to promote our major objective, including curriculum development and implementation of the curricula via numerous teachers' workshops and in-school activities, as well as carry out research that promotes the understanding of the teaching and learning of biology in high-schools.

Identifying students' scientific interests

Our group has initiated a pioneering effort to probe K-12 students' scientific interests using science and technology-related questions asked by children in free-choice (informal) learning environments, such as a series of television programs or internet sites. Analysis of more than 10,000 questions sent to both national and international internet sites indicated that the popularity of certain topics varies with age and gender. Significant differences were found between children's **spontaneous** (intrinsically motivated) and **school-related** (extrinsically motivated) **interests**. One outcome of this analysis, shown in Figure 1, suggests that a gender gap in students' interests in biology and physics is already evident among young elementary school children, before biology and physics are identified as such, and persists all the way to adulthood. Our analysis shows that the gender gap widens with age not because girls lose interest in physics with age as described in the literature, but rather because they do not seem to develop interest to the same degree as boys (Figure 1). The results obtained from our analysis of children's scientific interests constitute an empirical database for identifying contexts, which are more relevant to the interests and experiences of students. Thus, establishing a mechanism for designing learning and teaching materials which are aligned with students' interests.

Bringing contemporary biology into high-schools

Our group developed a concept to learn biology using **scientific research articles** that were adapted to the knowledge level of high-school biology students. We hypothesized that learning using primary literature may be a way of developing a capacity for scientific ways of thinking among students. We therefore examined the possible benefits of learning using adapted primary literature versus secondary literature, particularly with respect to their influence on the creation and formation of scientific literacy. We found that students who read adapted primary literature demonstrated better inquiry skills, whereas secondary literature readers comprehended the text better and their attitudes towards the reading task were less negative. In addition, we were recently able to show that learning biology using the adapted research articles promotes high school students' engagement with the subject matter, students' ability to integrate knowledge they acquired while learning other biological topics, as well as develop students' inquiry thinking skills.

Another way of adapting authentic scientific practices for the high-school biology students is to use internet-based bioinformatics tools. A learning environment, which includes interactive activities, based on genome databases, was developed in order to teach high-school biology majors basic ideas in genetics. The environment is aimed at giving high-school biology students a feel for how scientists work in the field, as it exposes them to some of the tools and resources currently available in experimental molecular biology. Recently we showed that when

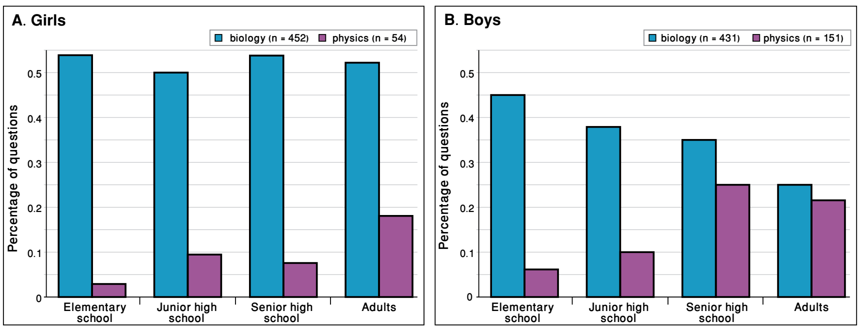

Fig. 1 *Developmental shift in the interest of girls (A) and boys (B) in biology and physics along four age groups, identified using self-generated questions raised by children, adolescents, and adults in the fields of biology and physics.*

students participate in the simulation of authentic genetics research and use the bioinformatics tools provided within the learning environment, they expand their understanding of the relationships between molecular mechanisms and traits, and refine their understanding of certain genetic concepts (Figure 2).

In line with our major objective, we recently developed learning materials in **genetic engineering** for high-school biotechnology majors. In these materials the main methods which are currently practiced in contemporary molecular biology laboratories are outlined alongside their possible applications. Practicing those molecular methods in the school laboratories is not feasible, due to the lack of appropriate equipment and experienced manpower. We attempt to make the learning materials less abstract to the students by providing both virtual and hands-on experiences. The learning materials are accompanied with interactive animations, which enable to view the molecular processes involved as well as practice problem solving activities on-line. We recently showed that the virtual experience is advantageous to learning. A significant advantage to students who learned about Polymerase Chain Reaction (PCR) using animations, compared to students who learned about PCR using still images, was identified (Figure 3).

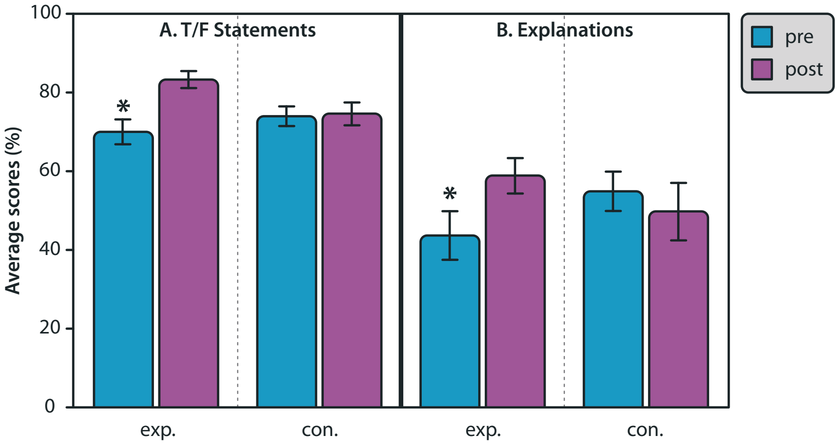

Fig. 2 *Comparison between students' ability to respond correctly to 12 True/False statements in genetics (T/F statements), and to provide explanations to their choices (explanations). The data was collected before (pre) and following (post) learning using the environment (exp.) or a textbook (con.). The data was analyzed using paired t-tests for the experimental (exp.) and the control (con.) groups. The asterisks symbolize significant differences between pre- and post-intervention (p < 0.0001, exp n=56, con n=39). The bars demonstrate the standard errors.*

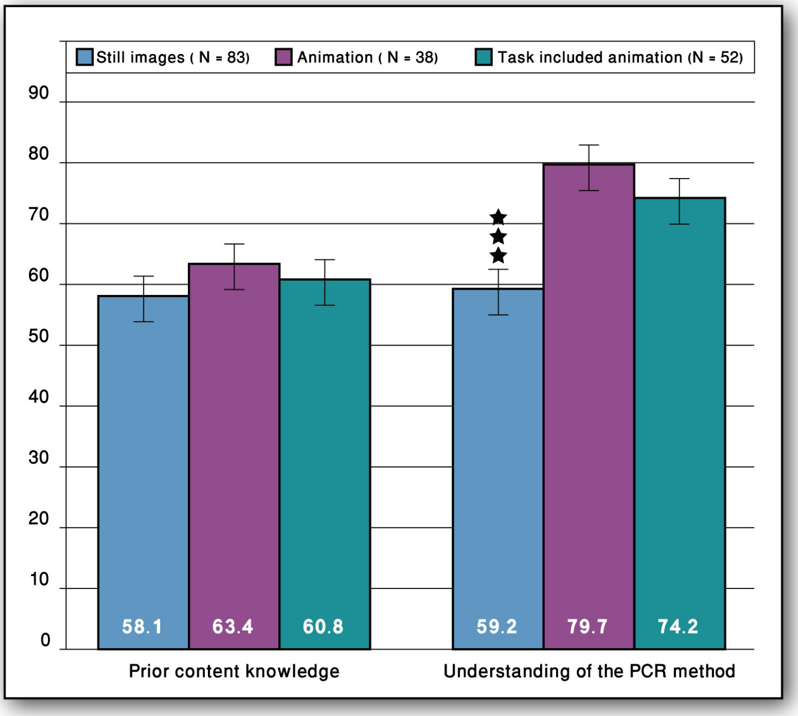

Fig. 3 *Students' understanding of PCR using various visualization tools: still images, animation and task-included animation. The three visualizations tools contain the same images and symbols. Students' mean scores in a prior-knowledge test (Left) and in a post-test (Right) are shown. p<0.001 (***).*

In addition, we designed and enacted modern **laboratory experiments** in molecular biology that can be carried out by high-school students and teachers in the laboratories of the Davidson Institute of Science Education, in the framework of The Center for Inquiry Labs, Nechmad project (in collaboration with the Davidson Institute). We were recently able to show that students' visual representations of plasmid DNA significantly improved following the activity as well as their procedural understanding with regards to DNA manipulations.

Student's interests, perceptions and routes for obtaining information and knowledge are subject to rapid changes, and are often ignored in the course of developing learning materials. At the same time biological research itself is progressing at an amazing pace, the outcome of which usually reaches the high-school classrooms only after a significant lag period. Our work has set the grounds for bridging between students' interests and the need to confer contemporary biological knowledge to the next generation, in an attempt to join these seemingly distant ends.

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