From memorizing information to thinking skills development-
The chemistry computerized laboratories program
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Research has emphasized both the theoretical aspects – fostering meaningful learning and critical scientific thinking, as well as the practical aspects – integrating hands-on experiments and visualizations into science teaching for better understanding of processes and phenomena. In addition, research indicates that constructivist and visualization-rich learning environments benefit students by fostering their mastery learning of scientific concepts and processes. This has influenced the design and application of instructional innovations by educators and curriculum developers. As part of this effort, computerized laboratories have gained recognition as important educational instruments in teaching chemistry.

During the last decade, the standard chemistry matriculation examinations in Israel have been enhanced by new modes of assessment. One major change in the chemistry curriculum includes the introduction of inquiry-based laboratory activities for which new study units were developed. The Case-based Computerized Laboratory (CCL) is a new chemistry learning environment that utilizes computerized experiments with an emphasis on scientific inquiry along with the analysis of case studies. CCL activities include understanding case studies, collecting sensor-generated data, constructing graphs in real time, and interpreting results.

The main objectives of our research were to investigate honors students’

- graphing skills and chemical understanding via bidirectional visual and textual representations in a case-based CCL learning environment, and
- near and far transfer skills.

The research population of our three-year study consisted of about 900 chemistry 12th grade honors students from a variety of high schools. CCL students' abilities in graphing and transfer skills were compared to those of non-CCL students. Both qualitative and quantitative tools were used including pre and post case-based questionnaires, interviews, and a reflection questionnaire. The research tools, pre and post case-based questionnaires, were developed and implemented based on interdisciplinary case studies. Students were asked to respond to case-based assignments which required higher order thinking skills, then, their responses’ content were analyzed and quantified.

We found that all the students in the CCL learning environment significantly improved their graphing skills, chemical understanding, and transfer skills in the post questionnaire relative to the pre-questionnaire. This improvement was observed at all three academic levels. Students' improvement in chemical understanding was manifest by their use of a greater number of chemistry understanding levels—macroscopic, microscopic, symbolic, and process—and higher quality of explanations. Comparing the experimental students to their non-CCL comparison peers show that CCL students demonstrated a significant advantage in graphing and far transfer skills. However, in near transfer skill, insignificant differences were found between students who were exposed to different types of instruction.

These research results may make a significant contribution to scientists’ and science educators’ understanding of thinking skills in general and graphing and transfer skills in particular. In addition, it might assist in developing and designing learning environments aimed at promoting higher order thinking skills.