Development And Validation Of A Tool For Diagnosing Conceptual Knowledge Of Chemical Bonding

Thesis for the degree DOCTOR OF PHILOSOPHY

Submitted to the Scientific Council of the Weizmann Institute of Science

Rehovot, Israel

By Malka Yayon

Advisors: Dr. David Fortus & Dr. Rachel Mamlok-Naaman

August 2011

Abstract

Chemical bonding knowledge is fundamental and essential to the understanding of almost every topic in chemistry, but it is very difficult to learn. This study describes the development of an automatic on-line tool that diagnoses basic conceptual knowledge of chemical bonding among high school students.

While many studies have characterized and diagnosed some of the central concepts of this topic, these concepts have not been systematically organized nor tested at a fine grain size. The design of the tool consisted of two main stages: A) the systematic characterization of the canonical conceptual knowledge of chemical bonding deemed relevant for high school chemistry majors in the form of a matrix, and B) the design of items and tests, their online version, and automatic feedback for two topics in chemical bonding, that represent the student's conceptual knowledge of chemical bonding compared with and linked to the matrix .

The matrix contains three strands: the structure of matter at the nanoscopic level, electrostatic interactions between charged entities, and energy aspects related to bonding. In each strand there are hierarchically ordered cells that contain fine grain concepts. The matrix represents what Reif called the "Final performance (Sf)" - what a student should know after learning high school chemistry. The tests were designed to assess the student's knowledge of this canon at different stages along the learning trajectory. In this way, representing the student's knowledge with the matrix can show changes from the "Initial performance (Si)" as learning is taking place.

Understanding of chemical bonding is more than just knowledge of the basic concepts, but without these basic concepts, a deep understanding of chemical bonding is impossible. Therefore, a diagnostic tool that can pinpoint the

concepts that are used correctly, incorrectly, or not at all could be a helpful instructional and research tool.

The development process described herein could serve as a model for the development of diagnostic tools which assess knowledge of other topics; a detailed evaluation of the tool, which describes its strengths and weaknesses, was performed.