Student Understandings of Solutions

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Abstract: This poster will present research about student understandings of solutions while observing dissolution and reactions first qualitatively and then quantitatively using ion-selective probeware. Preliminary data show that students have difficulty describing dissolutions symbolically and have difficulty choosing products in a double displacement reaction. The addition of quantification helps students reason about the identity of the substance in the beaker and the reaction that occurred.

Introduction

Solutions chemistry is important because it pertains to life, environmental and earth sciences as well as the field of chemistry itself. In chemistry, solutions imperative to reactions, concentration, and identity of chemicals. For example, cell biology studies the flow of solutions inside the cell through a semi-permeable membrane. One reason that students have difficulty learning to describe chemical phenomena is the use of different qualitative representation of matter by scientists (Johnstone 1982). Johnstone identified the different qualitative representations as submicroscopic, macroscopic, and symbolic. He defined macroscopic descriptions as the tangible and what can be seen, touched and smelt; submicroscopic as atoms, molecules, ions and structures; and the representational (symbolic) as symbols, formulae, equations, molarity, mathematical manipulation and graphs (Johnstone 2000).

There are three conceptual issues involved in solutions chemistry. They are Identity, Concentration, and Reaction. Identity is *what* is in the solution, Concentration is *how much* of it is in there, and Reactions occur in solution forming new substances. Reactions are different conceptually than Identity and Concentration because something new has been formed in this case. The three qualitative representations can be used to describe all three of the conceptual issues. A vast majority of the studies involving solutions chemistry looked at students' qualitative understandings (Johnstone 1982; Liu & Lesniak 2006; Nakhleh et al 2005; Mattox, Reisner, & Rickey 2006) concluding that students showed difficulty moving between the three representations of matter (symbolic, macroscopic, and sub-microscopic). These and other studies have a gap in that they do not address the use of number specifically within the concepts.

One review article (Çalỳk et al., 2005) discussed sixteen studies only one of which dealt with students reasoning about solutions (Gennaro, 1981). Three other studies point to the problems that arise when students are given numerical data in the context of solutions (Eliam 2004; Sanger & Greenbowe 1997, Calyk 2005). As seen in the literature, quantification is an aspect of solutions chemistry that experts seem to move effortlessly through in descriptions of phenomena. We believe that quantification is a 4th vertex to Johnstone's triangle, creating a tetrahedron of descriptions (Figure 1).

Methods

Nine students from a general chemistry course at an urban public institution in the Midwest were interviewed while they experienced different chemical phenomena. The tasks included: dissolution of copper(II) nitrate, reaction of copper (II) nitrate with sodium carbonate, reaction of copper(II) nitrate with sodium hydroxide solution, training with probeware, reaction of calcium chloride and potassium carbonate with probeware, and the reaction of calcium chloride with silver acetate. Students were video and audio taped and their drawings were collected. Students were encouraged to represent symbolically, macroscopically, submicroscopically, and quantitatively. The videotapes were transcribed and coded using NVIVO.

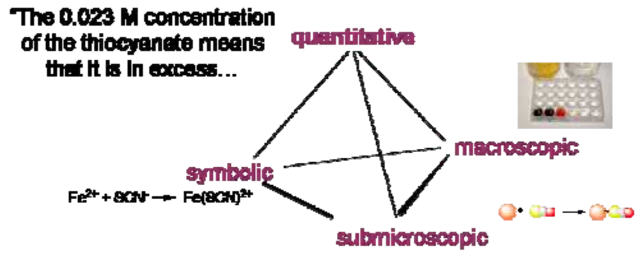

Figure 1: Tetrahedron of descriptions

Preliminary Results

Preliminary results yield several interesting findings. Two of nine students in the first part of the study forced a reaction of copper(II) nitrate with water for the dissolution of copper(II) nitrate in water when asked to represent it symbolically (Figure 2).

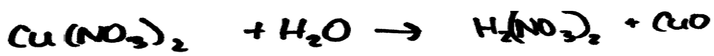

Figure 2: Student forcing a reaction when prompted to symbolically represent the dissolution of copper(II) nitrate

Several students were unable to predict the products for double displacement reactions using the probeware. This resulted in incorrect "flipping and switching" (two cations together) or in super-molecules that contained all of the ions involved in the reaction (Figure 3). Others chose the correct products but had difficulty reasoning with the concentration number for calcium to change or support their predictions.

Figure 3: Example of a "super-molecule"

We have preliminary evidence showing that especially in the reaction task where potassium carbonate is added to calcium chloride to form a precipitate, students are able to reason using the number output from the probeware. Because the calcium ion concentration falls drastically toward zero as it is no longer in ion form, students are able to reason that the precipitate must involve calcium.

Conclusions and Implications

Preliminary data show that students have difficulty describing dissolutions symbolically and have difficulty choosing products in a double displacement reaction. This is consistent with the literature reviewed earlier. Students have difficulty moving between the different representations. The addition of quantification helps students reason about the identity of the substance in the beaker and the reaction that occurred. With the revised protocol that emphasizes on probeware training, quantification has the potential to help students reason through their misconceptions of solubility, identity and reactions.

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