# Student Conceptions of Number in Solutions Chemistry

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Abstract: Students' understandings of number in solutions chemistry were probed through a qualitative study. Through the use of a semi-standardized interview, students' various ways of understanding number were pooled so that coding categories could be formed. Preliminary data show that students experience number differently with respect to molarity and significant figures.

## Introduction

The preliminary results of a full study, "Student Understandings of Solutions" have prompted another full study that examines how students understand number in terms of stoichiometry and significant figures within molarity. Students' conceptions of number are an important factor in learning because of the prevalence of number in many aspects of chemistry. This is especially true in solutions where measurements of mass, volume, moles, and concentration occur. An understanding of student conceptions of number affect instruction and learning in science, the use and refinement of standards, and efforts to understand how quantification helps or hinders student understandings of science, in particular chemistry. A qualitative study is being used in this research to document how students experience number, within the context of solutions chemistry. Specifically this study addresses the following research questions:

- What are students' conceptions of number in solutions chemistry problems involving molarity?
- What are students' conceptions of number with respect to molarity and volume?
- What are students' conceptions of significant figures in solutions chemistry?

A number without a unit in chemistry is useless because of all of these possible uses of number. In the same vein, because of all of the different possibilities for numbers in chemistry, students may have different conceptions of number for each possibility. Number is an essential component to the teaching of chemistry and students are often tested on their algorithmic skills. However, as studies suggest, students can perform algorithmically and have no understanding of the concept being tested (Nakhleh, 1993; Schmidt & Jignéus, 2003). This suggests that a study focused on students' experiences with numbers would be worthwhile. Solutions chemistry is a critical concept that connects to many other areas of science, such as earth, environmental and life sciences. Therefore solutions chemistry is an important area for students to master as they will encounter it many times in their academic careers.

Each state can create their own standards based upon the NSES and their own education requirements. Illinois has two sets of standards: the Illinois Learning Standards (ILS) which are the basis of the Illinois Science Assessment Framework (ISAF). A closer look at the ISAF statements shows that a vast majority of them involve number. Many of the statements are also related to solutions chemistry. Because more students are taking chemistry each year, we need to understand how they learn various concepts within the domain to better teach in the future

## Methods

In light of the importance of number in standards based education and the paucity of research on how STEM students experience number, I have chosen a qualitative approach to study the experiences students have with number in chemistry, especially solutions chemistry for a more complete study. Students were interviewed through tasks probing their understandings of number in solutions chemistry. For example, in one task three bottles are labeled with the same molarity but different volumes. Students are asked what is the same and what is different in the bottles. Another task, has four bottles with the same volume but four different molarities. Students are asked what is the same and what is different in the bottles. Finally, during a dilution task, students are asked what happens when 50mL of a 100mL solution of 0.15M $CaCl_2$ is taken away. All of these tasks are designed to find various ways of understanding number.

## Preliminary Results

Preliminary results from the larger "Solutions" project involving five students show that students are experiencing number with respect to molarity in a variety of ways. Students experienced molarity in an algorithmic way, citing the definition which is moles per litre of solution or they experienced molarity as a percentage of solution rather than the ratio that it is. For example, one student indicated that 0.05M was 5% less than 0.10M rather than being 50% less. This illustrates the need for further study of student understandings of number in solutions chemistry. An unusual preliminary finding that resulted from this study was that one student experienced molarity in relation to its significant figures, thinking that 0.05M was less significant than 0.10M because it has less significant digits and less was "looked at". Due to its unexpected nature, the task was not designed to afford this type of experience with number. This is another illustration of the need for further study of students' understandings of number in solutions chemistry as students held different conceptions than experts predicted. This is also an example of how a student could algorithmically solve a problem correctly yet hold a misconception about what the numbers mean. Instructionally, knowing what conceptions students hold with respect to number in solutions chemistry would facilitate student-centered learning. This could also inform the use of standards in that concepts of number could be tested rather than knowledge of an algorithm.

Finally, the dilution task revealed a conception that the molarity is decreased by half when half of a solution is poured out of the beaker. This conception does not involve the ratio of molarity, indicating varying ways of experiencing this type of number in solutions chemistry.

## Conclusions and Implications

The preliminary results from this qualitative study indicate the need for further study of student conceptions of number in solutions chemistry. A study of student conceptions of number in solutions chemistry would be beneficial to science educators on three levels. First, teacher conceptions could differ from student conceptions and being aware of those differences could allow teachers to design instruction that will bridge that gap (Orgill 2007). Effective instruction needs to address the conceptions that students bring to learning tasks, especially when the conceptions conflict and differ from those accepted by the community. (Bransford, Brown & Cocking, 2000). Second, participating students may become aware of their own contradictions as they reflect (Marton 1986, Orgill 2007). Third, other educators could use the outcome space to inform their work. A study of students' conceptions of number in solutions chemistry also has implications for our current research project, instruction in science, and the use and refinement of standards. Equipped with an outcome space of student conceptions of number, we could design better interviews to see if quantification helps or hinders student understandings of solutions.

## References

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