The Use of Taxonomy in Evaluating Student Learning in General Chemistry

Dennis C. Jacobs
Department of Chemistry and Biochemistry
University of Notre Dame

Students enrolled in CHEM 113 and CHEM 117 were given a series of identical questions distributed over 20 exams across four semesters. These common multiple choice questions were representative of the entire range of questions students were asked in the course. The two classes differed in student composition. CHEM 113 was composed primarily of students who scored at or below 630 on the Math SAT. CHEM 117 was filled with students who scored higher than 630 on the Math portion of the SAT. CHEM 113 covered the same material as CHEM 117 but included mandatory homework assignments and weekly collaborative exercises.

The 118 common questions used in Fall '97, Spring '98, and Fall '99 were categorized according to a number of classification schemes. The average student performance for each class of problems is plotted in the following graphs.

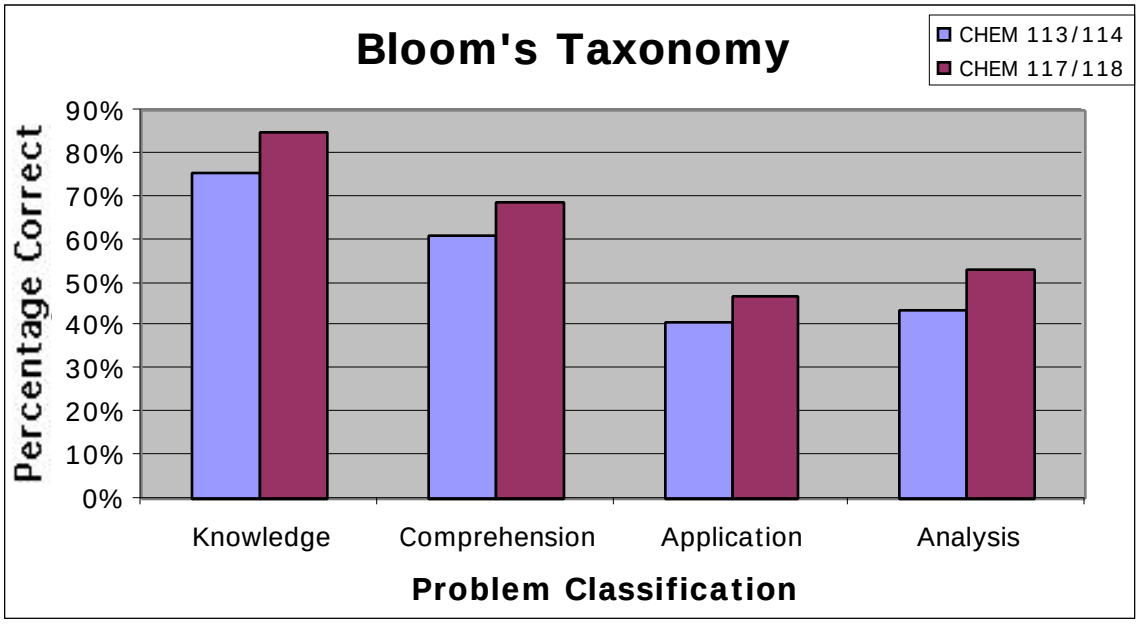
I. Bloom's Taxonomy

is a classification of education outcomes (Benjamin S. Bloom et al., *Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain* (New York: David McKay, 1956, Longman Publishing Group). We found that Chemistry test problems could be sorted into one of the first four classifications of Bloom:

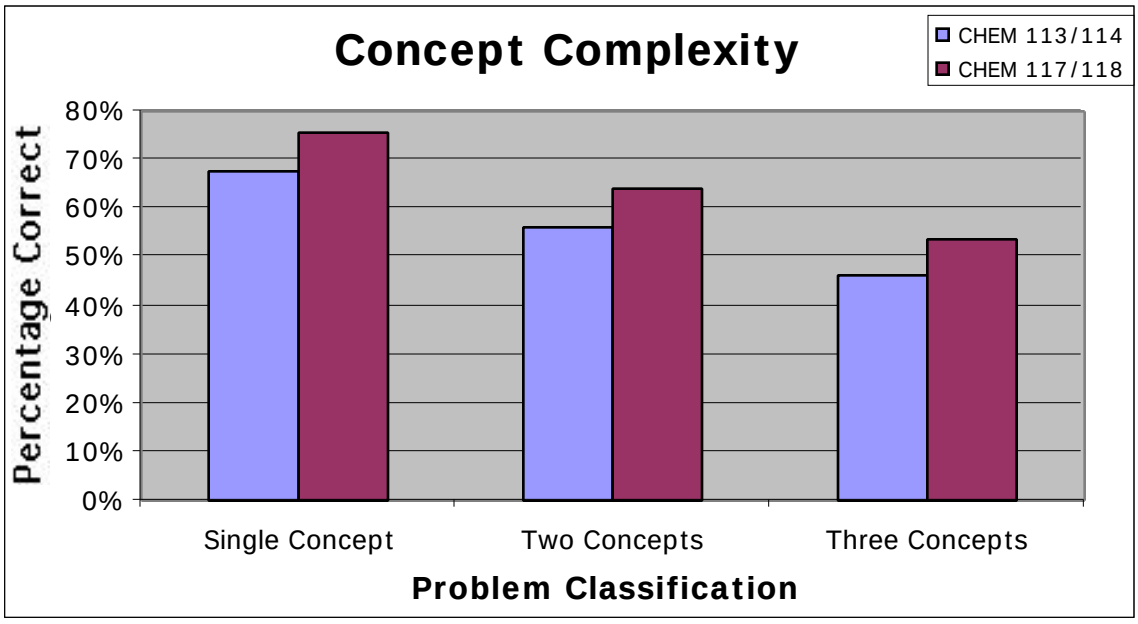
1. Knowledge – recall of memorized ideas
2. Comprehension – understand what is being communicated (translation, interpretation, extrapolation). Solve problem using a method that is explicitly specified.
3. Application – student applies appropriate abstraction to solving a new problem without being told to do so.
4. Analysis – break down material into constituent parts and detect relationships of the parts and how they are organized.

Because students in the two courses were taught by different instructors, it was difficult to distinguish which problems belonged to categories 2 versus 3. Whether a problem is seen as new depends on the precise set of problems a student has experienced in lecture and homework.

Students tended to score higher on questions of the first two types than the latter types. It is generally accepted that Bloom's classifications are listed in order of increasing cognitive function.



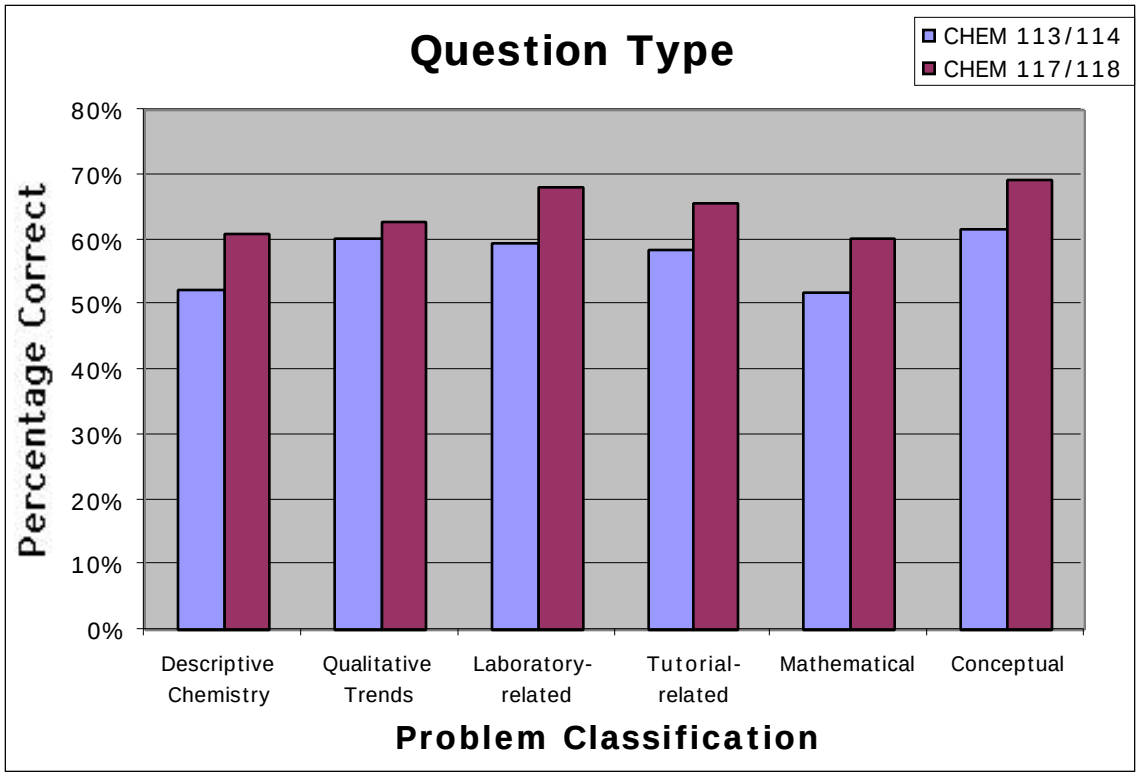
II. Number of Concepts A more objective classification scheme than Bloom's taxonomy is to categorize problems according to how many independent concepts a student must integrate in order to form a complete solution. As expected, students perform better on those problems which require the use of fewer concepts.



III. General Problem Types

Common questions were also categorized according to whether students were asked to:

1. Predict chemical behavior or the products of a reaction
2. Rank chemical species according to their physical or chemical properties
3. Answer a question on a subject covered in the accompanying laboratory
4. Solve a problem similar to one experienced in one of the cooperative learning sessions
5. Find a mathematical solution to a problem
6. Answer a conceptual based question.



IV. Summary

In all of the above classification schemes, the CHEM 117 students outperformed the CHEM 113 students. To better assess the impact of CHEM 113, a similar analysis of test performance should be performed on "at-risk" students who took General Chemistry prior to the advent of CHEM 113. However, the test item data from three year years ago has not yet been retrieved.