PEER-LED TEAM LEARNING
LEADER TRAINING

ALGORITHMIC PROBLEM SOLVERS OR CONCEPTUAL THINKERS: WHICH IS MORE FAVORED IN CCNY'S CHEMISTRY COURSES?

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Science in the classroom, and chemistry in particular, is not adequately applied to the outside world. Students learn about the gas laws, but are the gas laws seen as relevant to anything outside the classroom? These remarkable concepts are often remembered merely in the form of an equation. Once one is given the necessary data, a numerical answer can be obtained by the use of a formula. This algorithmic process takes little mental effort and can be mastered if repeated several times. It is unfortunately accepted as a testing method in the introductory chemistry courses (primarily for science and engineering majors) at the City College of New York as the prime indicator of acquired knowledge.

Is true understanding attainable through the memorization of a formula? Of course not. However, the use of algorithms is an efficient way of testing. While not everyone is pleased with this method of evaluation, it is used at City College. This research paper is an analysis of the introductory chemistry course, its algorithmic vs. conceptual side, and how much emphasis is placed on each aspect.

Humans are creatures of habit and we tend to learn best by repetition. We practice with the intention of perfecting our skills. Loosely speaking, any step-by-step method can be considered an algorithm. However, for the purpose of this paper, we will think of algorithms as mathematical operations performed in some form of structured, cohesive manner. The balancing of an equation for example is algorithmic. This approach to learning may be preferred by many students and instructors alike as easy to master and easy to grade. There are, however, a peculiar few students who are more fascinated with a concept than its reduction to an algorithm.

Conceptual thinkers are normally out-numbered by algorithmic problem solvers in the average chemistry classroom. The conceptual students, referred to as the *second tier* by Nakhleh (1993), are more concerned about the *why* than the *how* for a particular concept. While the algorithmic student is satisfied with getting an answer, a number representing the partial pressure of a gas, the conceptual student is more intrigued by the orientation and rate of collision of the molecules. While it can be argued that it is more important to understand the concept because numbers can always be changed, what is taken as evidence of understanding is the recorded grade. That grade is determined by the successful execution of algorithmic steps. It seems logical that with the understanding of a concept, the algorithm should be easy. It should be noted, however, that the time needed for true comprehension of a concept far outweighs the time needed to memorize a formula and practice a few examples. The average introductory chemistry lecture sessions at City College last three hours per week, and the time allotted for workshop is nearly two hours. During a week, several subtopics may be covered. In trying to fully understand a seemingly complicated topic such as the quantum theory, along with the pressure of other courses, and everyday life, the conceptual student is placed at an obvious disadvantage. Chances are, when the exam comes around, only two out of a total ten points for a particular question are conceptual. The remaining eight points are totally algorithmic.

To quantify this hypothesis, the topics covered on the course syllabus were categorized according to their algorithmic or conceptual content. These categorizations were somewhat subjective. This task of classifying the general topics was a challenge in itself: certain topics could be considered equally conceptual and algorithmic, and were placed in a sort of algorithmic-conceptual hybrid class. All the topics had a mixture of both a conceptual and algorithmic aspect, even if disproportionate. After all, there must be a concept behind all scientific belief, whether factual or theoretical. For research purposes though, topics were categorized according to how they were traditionally tested. From a total 13 topics, seven were exclusively algorithmic, four were in the hybrid group and the remaining two were under the conceptual banner.

For example, the topic of thermochemistry was placed in the algorithmic category because all the questions on the last three exams required only calculations. It is possible for an instructor to ask for an explanation concerning the enthalpy changes occurring during the bond-breaking process. Usually, though, this does not happen.

Learning styles have a direct relation to conceptual thinkers and algorithmic problem solvers. Sequential learners, according to research conducted by Gregorc (1982) , are practical, methodical, ordered and prefer a sequential, step-by-step approach to doing things. A learner with these characteristics is undoubtedly algorithmic. The Random learner, according to Gregorc, is inventive, emotionally attached to the material and even has an inner guidance system. The conceptual thinker would fit the description of Gregorc's Random learner more closely than the algorithmic student. It can be said then that learning styles are determining factors in the efficient transfer of knowledge, and should be considered by those responsible for guidinganother person on the path of learning. Most importantly, workshop leaders, who are expected to have a closer bond with a student than a professor would, should be familiar with the different learning styles and the type of student they are trying to help, whether that student is conceptual or algorithmic.

In a survey completed by 24 workshop leaders, twelve leaders stated that they always consider different learning styles when they plan for their workshop, eight usually do and four factor in different learning styles on an occasional basis. If workshop leaders are not sensitive to the few conceptual students, then the odds which are already stacked against the conceptual students will only increase. Ten of the 24 workshop leaders surveyed think that our current workshop materials are too mathematically oriented (as even the second half of the introductory course is biased toward algorithmic problem solvers). Yet workshop materials often include conceptual exercises, such as concept maps, modeling and visual organizers (Gosser, *et al.*, 2001).

The final exam, unfortunately, is a different story. The final, composed by a group of three faculty members, carries most of the weight for the student's overall grade, and has shown an increase in the number of points awarded for algorithmic questions between the Fall 1999 semester and the Fall 2000 semester. The total number of points allocated to algorithmic questions, according to the general categorization of topics, rose from 48% (the exam has a total of 100 points) in the Fall of 1999, to 53% and then to 64% in the Fall 2000.

It is obvious which of the two types of students are favored by City College's introductory chemistrycourses. Is this a bad thing? It is traditional to use the algorithmic-based form of evaluation at this level, thus making it the usual method of testing. Higher-level chemistry courses may pay more attention to conceptual matters. The conceptual method relies more on an explanation which gives room to ambiguities, the opinions of students, and perhaps the leniency of the evaluator.

Most students have grown accustomed to the algorithmic method of problem-solving and so a radical change in the evaluation method might meet with initial resistance. Instead instructors and workshop leaders should try and implement more conceptual methods of testing over a prolonged period of time. Algorithmic problem solvers are the majority in the science classroom. Despite being fewer in number, the conceptual students' approach should still be considered more often for deeper understanding by all types of learners.

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