CONVERTING "CONFIRM THE LAW" EXPERIMENTS INTO "INQUIRY" EXPERIMENTS (#7.1)

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"Confirm the Law or Principle" Experiments

The basis of a "confirm the law or principle" experiment is to give the students careful directions on how to set up the equipment, how to conduct the experiment, and how to analyze the data. Because the beginning chemistry student lacks the chemical background and laboratory skills necessary, initial experiments should be devoted to building this basic laboratory background and skills. For experiments that use the ***MicroLAB*** interface, these beginning skills may be developed by using the manual **Measurement, the Basic Science,** published by Hayden McNeil, where the student is introduced to computerized data collection, using various sensors such as temperature, pressure, pH, and colorimetry to collect data, using that data in making and interpreting graphs, etc. This manual takes students through the first two or three lab periods, at the preference of the instructor. An exercise that is particularly helpful to students in this early stage is **An Exercise in Organizing and Analyzing Experimental Data**, (Experiment 9.1 or 9.2 on the CD**)** which leads the students through the steps listed below to help them understand the use of graphing (either using the ***MicroLAB*** spreadsheet or **EXCEL**) and mathematical modeling to better understand the relationships of experimental variables to each other:

a. The roll of models in science.
b. Using graphs to identify mathematical models.
c. Regression analysis and the correlation coefficient.
d. Predicting from the model.
e. Linearizing non-linear data to determine the variable relationships
f. Six directed Non-linear examples involving power functions, inverse relationships, etc.
g. Three completely independent examples.

One then begins to build chemical knowledge and laboratory confidence with additional "confirm the law or principle" experiments, interspersing a "guided inquiry" experiment here and there as they build confidence, and toward the end the semester, introduce one or two "pure inquiry" experiments. The second term can then build on this basis by introducing more "guided inquiry" and "pure inquiry" experiments.

Guided Inquiry and Pure Inquiry Experiments

The purpose of the guided inquiry experiments is to begin weaning the students away from the "cookbook" approach of the "confirm the law or principle" type experiments, and to begin guiding them towards thinking out the experiment for themselves in terms of (1) what are the variables involved, (2) which of these variables are dependent and which is the independent variable, (3) how can these variables be controlled so that the data is meaningful, (4) what experiments need to be designed to gather preliminary information upon which to formulate hypotheses, (5) how to go about formulating hypotheses, (6) how to devise experiments to test those hypotheses, (7) how to analyze the data from those experiments, etc. This is nearly always a totally new experience for the students, and often is a shock to them. They need to be guided into that mode by providing sufficient information in the beginning that will help them begin to think through these questions. Consequently, "guided experiments" early on in the term should provide more help than those later on in the term. Additionally, since each instructor, as well as the backgrounds of the collection of student are unique to each classroom, it is best for each instructor to determine when directed

inquiry should be introduced, and how much help is to be provided at each stage as the students progress. Figure 1 visualizes the process we are trying to get the students to master. The student is presented with a problem, for which he/she needs to obtain a solution. The students are given a preliminary experiment design, which in the beginning is more detailed, but as they progress, the detail is shifted more and more for them to work out. They carry out the initial experiment, acquire the data, then organize it and try to draw conclusions concerning whether they have solved the problem. If they adequately understand the problem, then they have arrived at their solution. If they do not yet adequately understand the problem, then they must further discuss the problem, seek additional resources to shed more light on it, redesign their experiments in light of their new information and repeat the process from experiment to acquire data to organize and draw conclusion and again determine if the adequately understand the problem. This is known as the Axiomatic-cum-pragmatic cycle, where axioms or postulates about the problem are made, the experiments are carried out, and the results correlated back to the beginning postulates for confirmation.

n light of the above discussion, one can see what is necessary for the "confirm the law or principle" type experiment to be converted to "guided inquiry" experiments simply by revising the text version of the experiment found on the CD that can be purchased from **MicroLAB, Inc** at PO Box 7358, Bozeman, MT 59771-7358, or from Hayden McNeil Publishing at 14903 Pilot Drive, Plymouth, MI 48170, Main Phone: (734) 455-7900 Fax: (734) 455-3901.)

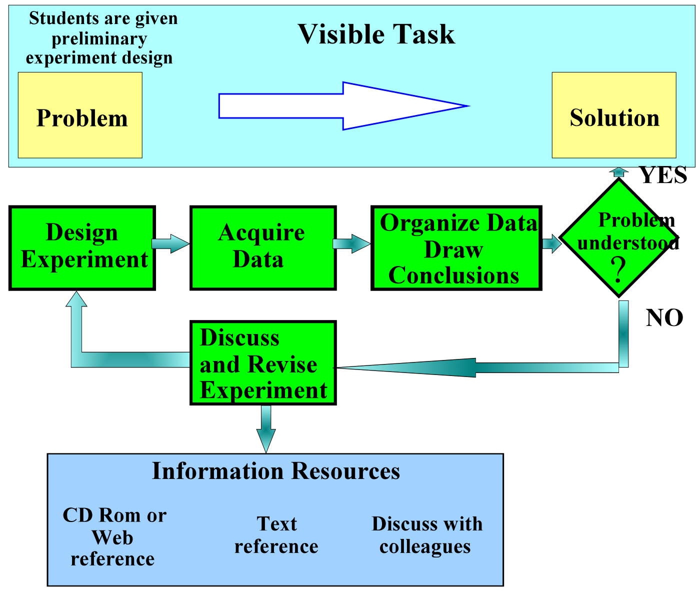

Figure 1. The guiding philosophy used in developing the ***MicroLAB*** software, involving successive cycles of design, acquire, organize, discuss and revise to obtain the final solution to the problem.

Transforming one into the other

This transformation is accomplished by simply reducing the specific directions in the student version, initially providing extensive instructions to the initial experiment, and as the semester progresses, providing less extensive instruction in the initial experiment until near the end the experiments have evolved into "pure inquiry" where the students are given only the problem, and are required to complete all of the above listed steps on their own. Some students will readily adapt to this type of experiment, but others will struggle with it. They have not had any, or have had very few experiences in their past education where they have actually had to think something through for themselves. Be patient with these students, struggle with them, and they will eventually begin to get their brains in gear and produce. The best way I have found to do this is to use the Socratic method, i.e., I answer their questions with a series of questions designed to lead them through to the answer to the question they asked. This is frustrating to many of the students because they want answers, not more questions. However, I have found it pays off with great rewards in the end. I have had many student indicate on evaluations that I was the hardest teacher they ever had, then several years later I would get an email or letter from them thanking me for making them work hard and learn how to think because they were finding they were doing better than many of their colleagues because they had learned to think for themselves and had mastered the basic material.

I have found the ***MicroLAB*** interface one of the best tools to help students of chemistry understand the laboratory aspect of chemistry. It is a whole new way of teaching Chemistry. The main screens are easy to understand, the operation is intuitive, and the data analysis is fairly straight forward. The observation of the graph formation as the experiment proceeds is an eye opener for the students. One of the main problems experienced in lab is that the computer screens become smeared with finger prints from the discussions that go on between the students, and students and instructor and have to periodically be cleaned, a welcome chore. As in all computer programs, there is a learning curve, but the instructions and power points that come with ***MicroLAB*** and the CD mentioned above will quickly help your students become proficient in its use. If you have any problems while working with these experiments, please contact me at the information below, I will be more than happy to try to help you out.

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