Introduction

Much recent attention in chemical education has been focused on the need for "problem-based" learning strategies in the teaching laboratory. Industry and government analytical chemists are concerned that recent chemistry graduates have only a technique-based perspective on chemical analysis instead of viewing chemical analysis as an integrated process based on problem solving. Thus, in academia's zeal to provide hands-on exposure to every new instrumental analysis method that is developed, education of students in the integrated concept of the "analytical process" has been lost.

Materials Characterization Project

The idea for a Web-based chemical education tool lies in a laboratory activity implemented in the first-year graduate analytical laboratory at the University of Arizona. This activity was introduced into the curriculum in an attempt to rectify the perceived problem-solving deficiency of new analytical graduate students.

This project involves the complete chemical analysis of a commercially obtained product or formulation by the student. After being given the product, along with a series of specific questions intended to guide the student's activities, the student is responsible for articulating the entire analysis problem, conceptualizing solutions through information gathering, identifying the analytical method or methods needed for answering the questions posed, designing the experimental protocols, acquiring the data, analyzing the results, writing a report and making an oral presentation of the analysis. In short, the student is responsible for the entire analytical process on their product.

Over time, the pedagogical value of this exercise became evident, and a version of this project for the undergraduate instrumental analysis laboratory emerged. At the undergraduate level the Materials Characterization Project is a two-to-three-member team activity spanning a four week period of time that uses similar products to those analyzed by the graduate students.

The Materials Characterization Project has been a unique tool for teaching students the analytical process and developing their problem-solving skills. An instrumental laboratory endeavor such as this relies heavily upon the instrument facilities and human resources at the University. These resources may not be available to students at all academic institutions who wish to implement such a laboratory experience. Small
four-year academic institutions are especially likely to be missing some of the larger instrument facilities such as Electron Microscopy and Surface Analysis that are so very important in real-world industrial materials analysis laboratories.

**Materials Characterization Project Website**

In order to overcome the problems that smaller schools and institutions would encounter trying to implement a laboratory course similar to the University of Arizona Materials Characterization Project, a version of this lab course is being developed as an interactive, hypermedia-based experience on the World Wide Web.

The basic idea of an interactive Web-based experience for students in materials characterization requires the student to chemically analyze several major components of a common commercial product by defining the analysis approach, selecting the analysis method(s), designing the measurement experiments, "collecting" the data, interpreting the data, and arriving at conclusions about chemical composition and content based on the data. In order to teach the analytical process, it is imperative that this Web-based experience be structured in such a way that the *student directs* the analysis, not the computer program directing the student. Thus, this Web-based experience is determined by the progress of the student through "dynamically" generated documents.

These "dynamic" documents are created by the combination HTML formatting and content that is seamlessly incorporated into new documents that are served to the students Web browser, Figure 1. The architecture for the Materials Characterization Project Website (MCPweb) is a combination of relational databases created using Microsoft SQL server and CGI (Common Gateway Interface) scripts written in Perl (Practical Extraction and Report Language). Perl is an interpreted language optimized for scanning arbitrary files, extracting information from files and databases, and creating web pages based on that information.

Every effort will be made to make the instrument simulations realistic; to that end an extensive database is being created that contains a wide range of data quality. This simulation will be able the students to experience "virtual failure" as well as success, thus reinforcing the problem-solving pedagogy of MCPweb.