INTRODUCTION OF STRESSED STREAM ANALYSIS MATERIAL INTO THE CHEMISTRY CURRICULUM AT WELLS COLLEGE: 1995-96

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Overview: Dr. Bailey revised his freshman-level introductory chemistry laboratories by presenting students with problems that required them to design their own experiments and develop an understanding of fundamental chemical concepts while learning how to perform routine analyses. He also incorporated techniques learned in the stressed stream analysis program into new aquatic biology and environmental science courses.

Introduction.

This paper reports on some of the activities that I have engaged in this year, and am planning on for the coming year, related to Stressed Stream Analysis. The paper is divided into two parts. The first reports in more detail on the indirect, albeit important, introduction of a particular aspect of the Stressed Stream Analysis experience into my General Chemistry courses this past year. The second reports briefly on some of the direct applications of the Stressed Stream Analysis material that I will introduce into the curriculum at Wells in the coming year.

I was initially approached in January 1995 by members of Wells College's new major program in Environmental Science, Policy, and Values, about the possibility of my teaching a course in Quantitative Analytical Chemistry that their majors could take. I did not at that time have much first hand experience in the environmental aspects that such a course would entail, and so I was initially hesitant to agree to teach this course. However, a day or so later I received the flier advertising the Stressed Stream Analysis program and, knowing augury when I see it, applied for participation. Taking part in the SSA program certainly allowed me to make more informed decisions concerning the Quantitative Analytical Chemistry course and allowed me to introduce various new ideas related to environmental analysis to the Wells community.

Indirect Application of Stressed Stream Analysis Material
My attendance in the Stressed Stream Analysis program has already had the greatest impact in the way I present and teach my General Chemistry laboratories. This change was not a simple translation of the techniques and exercises that we performed last summer (as are many of the activities I have reported on above), but was a bit more subtle. Although this change is on the surface a simple one, it has already proven to be quite successful both in terms of pedagogy, and student acceptance and performance.

One of the aspects of the Stressed Stream Analysis program that I found most intriguing was the idea of context--the idea that this program wasn't just a chance to learn about various techniques, but that the results of those techniques would be used to solve an overall (albeit fictional) problem. This program could have been set up so that we learned about water analysis, and biotic indices, and environmental impact statements as important tools for use in our classes. And that would have been fine. But, what really made the SSA program interesting and exciting for me was the idea of a wastewater treatment plant preparing to increase its capacity to accommodate both an increase in local population and discharge from a new Lead Recycling plant, and the idea that we would, through our investigations, have a say in that project. We worked especially hard those last couple days writing up the Environmental Impact Statements--and had fun doing so. Would we have worked as hard if we had simply been asked to write up the results of the various studies we had performed the previous two weeks? I don't think so.

I wanted to bring some of that sense of purpose and excitement to my students. So, last summer I rewrote each of the laboratories for my first semester general chemistry course and adapted them to include the idea of context. I should point out that many of the laboratory procedures are almost identical to what I have used in the past, the biggest difference being that I changed the context in which these laboratories were performed.

At the beginning of the semester the students were informed that they, as members of my course, were also employees of GenChemCo Industries. Then, at the start of each lab period, they were given a letter written to GenChemCo Industries by some outside individual (i.e., "the client") requesting that our company provide them with some particular piece of information. Along with this letter was an "InterLab Memo," written by me, outlining the procedures they were likely to perform that day. Note that there was not a lab manual for the course and that the students all arrived at the beginning of the lab period not knowing what they were going to be doing that day. In addition, the labs were mostly performed prior to covering the intended material in the classroom. After reading both the letter and memo, the students got together with their lab groups (I have been using cooperative learning in this course for six years) and devised a plan of attack. Most of the labs were designed so that an individual group could not complete the lab without information/data/help from other lab groups. The experiments were performed, group data was shared, and a class discussion was held to determine if an appropriate response to the client could be given at that time, or if additional information/experiments were required (many of the labs were set up so that the students had to think beyond the given protocol). Thus, the students could not simply follow a cookbook recipe and leave (as is a problem with many general chemistry laboratories); they had to think about and interpret their results on the spot.
Following the laboratory, the students then had a week to formulate a response to the client who had originally written the letter to GenChemCo Industries. This response also had to be in the form of a letter. This turned out to be one of the best activities I have ever had my classes perform. Not only did the students have to present and interpret their data as they would in a regular lab report, but they also had to relate it to someone who was obviously not in the lab with them at the time. Their presentations had therefore to be succinct, intelligible, and written in proper English!

Appendix 1 provides an example of a typical laboratory write-up from early in the semester. This example shows how the labs were structured, and how content played an important role. The first page is a letter from the client asking for information and setting up the context for the lab. Here the question put forth by the client (Coins `R' Us) is "What is the measurable effect of age on [a coin]?" The second page, the InterLab Memo, asks the students to propose a plan of attack and/or propose hypotheses for responding to the client. It also normally would give them minimal procedural information to perform the laboratory. The students are asked to predict an answer to the client's question and to propose a means of proving/disproving this hypothesis. For this particular lab the student predictions fell into three general groups: a) mass of coins increases with age (due to tarnish), b) mass of coins decreases with age (due to wear), c) mass of coins doesn't change. It should be noted that in the lab write-up the term "mass" is never mentioned; the students introduced this concept on their own. Each group was then given a limited number of coins that they weighed on an analytical balance (the use of which is one of the underlying purposes of this lab). The class data was then collected and plotted in order to determine which of the three hypotheses was correct.

As can be seen in the graph in Appendix 1, NONE of the hypotheses were correct. There wasn't an observed gradual change in mass with time, but a large single drop in mass around 1982. The class then reassembled to brainstorm again and to rework their various hypotheses. The typical revised hypothesis proposed at this point was that the volume of "the product" had changed. This was tested by displacement of water (a student generated idea), only to find that the average volume of the post `82 coins was the same as the pre-82 coins. This led to a discussion of density (which was the actual purpose of this lab), the fact that density is an intrinsic property, and therefore that the two sets of coins must be made from different materials! This led the students to decide to respond to Coins `R' Us that a significant change in the product had already occurred and that the company might want to investigate that.

As you can see, this lab is presented in the "discovery" format. I used to perform a similar laboratory where we would first, in the pre-lab discussion, talk about density and then verify the concept in the lab. Here there is no previous indication that density is a consideration in this lab, the students must discover it for themselves.

Appendices 2, 3, and 4 provide additional examples of client letters setting up the context of the respective labs. The procedures associated with each of these laboratories
are fairly common and probably are performed at many institutions. What is different here is the context under which my students performed these labs. Appendix 2 is the letter for a typical Vinegar Titration laboratory (determining the percent by weight acetic acid in vinegar), here set up as the outsourcing of an investigative effort by the FDA (the Feasting and Drinking Administration). Appendix 3 is the client letter for a Copper Content of a Dime lab, here set up as an investigation of potential embezzlement at Coins `R' Us. Appendix 4 is for a standard Aspirin lab (determination of acetyl salicylic acid in aspirin), here given the context of a Consumer-Reports-style testing for the American Headache Society.

Assessment of Student Response

Student response to these changes in laboratory context was overwhelmingly positive. I detected a marked increase in the students' interest and sense of purpose in their approach to laboratories; this change has certainly minimized the "are we done?" syndrome. Students were more fully engaged in what they were doing in the lab and typically stayed longer than required in order to fully answer the given question.

I had initially designed the labs so that only a few included a letter of response to the client. However, after the first several labs I discovered that this mode of response was most successful in getting the students to think about and to care about what they were doing. The idea of having to present their procedures/ideas/results to some other person (even fictional!) caused the students to work hard on the clarity of their presentations, and certainly helped them to improve their communication skills. The letters were so much better than the "simple" lab reports from previous years that I made the letter of response the primary mode of report for the remaining labs. It was also much easier to get the students to understand and accept critiques of their work; it was somehow easier for the students to be concerned when told "Your job at GenChemCo Industries is on the line if you keep sending unintelligible letters to our clients", than "If you want to pass this course you really need to work harder on your writing." Overall the students actually worked harder than I would have anticipated on these letters (especially when compared to what would have been the corresponding lab report in previous years), but they also seemed to enjoy doing so--just as we enjoyed writing up our Environmental Impact Statements. I also found that the students' drive and enjoyment carried over into the lecture portion of the course as well.

It may be obvious that I was very satisfied with the general student performance this year; this was certainly one of the best classes I've taught at Wells. But, how can I be so sure that the students were satisfied with my performance this year? They nominated me for, and I received, the 1996 Wells College Excellence in Teaching Medal; I am the first science faculty member to receive this honor.

Direct Applications of Stressed Stream Analysis Material
One of my first activities in the fall was to present a talk, relating my Stressed Stream Analysis activities, to our weekly science colloquium. I included in this talk a discussion of what the Stressed Stream Analysis program was all about, an overview of the Waste Water Treatment Plant expansion project, the use of Environmental Impact Analysis as a theme, the numerous analyses we performed (water quality, loadings, biotic indices, etc.), and the various recommendations and alternatives we proposed. The presentation went over quite well with both faculty and students. The talk has also directly resulted in the following:

A. I have been invited to become a member of the Environmental Science, Policy, and Values major program. This group will now consist of a biologist, a chemist, an economist, and a physicist.

B. I was asked to sit in on the Environmental Studies 101 course this coming fall to learn about what they are already doing in the course so that I can suggest additions/modifications based on my Stressed Stream Analysis knowledge, and also so that I can possibly take a rotation teaching this course in the future.

C. I have been asked to edit/contribute to an in-house publication entitled, "Environmental Problem Solving in the Cayuga Lake Basin". This book will be utilized in a sophomore level Environmental Studies course. I have already edited the previous (1994) edition and have thus far contributed two additional exercises ("Local Land Use Patterns" and "Stream Discharge and Loading") based on the Stressed Stream Analysis project. I may also sit in on this course, and will certainly supervise the various exercises I have contributed.

D. I was asked to not teach the course in Quantitative Analytical Chemistry (the course for which I was involved in Stressed Stream Analysis in the first place), but to instead help revise and team teach a course in Aquatic Biology this coming year. I will introduce Environmental Impact Analysis as an overriding theme for this course. I will also be responsible for the sections on Hydrological Analysis and will assist in teaching Biotic Indices (including "kick and pick" and seining collections). I have also gotten my fellow faculty member really excited about the possibility of electrofishing.

The "project" that the students will be examining for their Environmental Impact Analysis Statements will be the development of "Sandy Springs Acres", a proposed retirement community near Aurora. The intended site is located about a quarter of a mile uphill from Cayuga Lake and borders a local stream; it is also about a quarter mile from the local waste water treatment facility and so would add to that facility's capacity.

I will also be adding a multi-week laboratory exercise in hydrological analysis of local waters (put together by chemists at Skidmore and Sweet Briar Colleges as part of the CURI project, also funded in part by the National Science Foundation) to my second semester general chemistry course.

NEED TO SCAN/ADD APPENDICES 1-4; SSA 1996, pp. 12-17.