NEW LABORATORIES FOR QUANTITATIVE ANALYSIS

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Overview: Dr. Alexander created new laboratory exercises for phosphorus and metals and co-authored an NSF proposal to upgrade knowledge and technical skills of 2-year college faculty.

Introduction

As a result of the Great Lakes Research Consortium’s Ecosystem Dynamics practicum, two laboratory exercises were created and incorporated into my Quantitative Analysis course. The phosphorus lab (Appendix 1) was partially inspired by the P-model activities that were part of the practicum. The sediment analysis lab procedure (Appendix 2) is a slightly modified version of the method learned at the practicum.

Both labs went over well with my students. The students enjoyed the chance to see how quantitative analysis applies to real life. The sediment analysis lab allowed them the chance to collect samples in the field at Lake Winnebago, and to process and analyse real samples in the lab. They also learned how much care must be taken to prepare a sample from beginning to end to assure proper results. The two problems we encountered were finding a good site to take sediment samples and access to proper instrumentation. Next time I will try to find a site with high lead concentrations to make it easier for students to see results. Lawrence University was kind enough to allow us to spend an afternoon on their AA, but I can not be sure of that use every year. Also, with increased class size, it will be difficult to use their facilities.

In the phosphorus lab, students were impressed to see they could actually get very accurate results using a visual spectrophotometer. They were required to find the amounts of organic phosphate, condensed phosphate and orthophosphate in water samples. Although they found the process tedious, in the end they felt the results were worth the time spent. I would not change anything in this lab.

Grant Proposal

Discussions at the Practicum about grant possibilities to support undergraduate teaching stimulated Paul Martino (another 1992 participant) and me to co-write a proposal (Appendix 3) to NSF titled, “Improving Science Education in the UW Centers: Workshops for Science Faculty,” The proposal seeks to establish a coalition between the University of Wisconsin Centers, comprised of 13 2-year campuses, and two 4-year institutions: UW-Eau Claire and UW-
Green Bay. The primary objective of the coalition is to help the two-year faculty learn of new advances in their disciplines, and to help them incorporate these developments into their classes. Coalition activities will include summer workshops and follow-up activities during the academic year. Workshops will be multi-disciplinary, including biology, chemistry, physics, geology and engineering. The Coalition will bring 2- and 4-year faculty together for cooperative research.
Appendix 1

PHOSPHORUS ANALYSIS OF WATER SAMPLES

BACKGROUND

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. They also occur in solution, in particles or detritus, or in the bodies of aquatic organisms. Condensed phosphates are used in water supplies for treatment, laundering or other cleaning and the treatment of boiler waters. Orthophosphates are applied to agriculture or residential cultivated land as fertilizers. Organic phosphates are formed primarily by biological processes. They are contributed to sewage by body wastes and food residues, and also may be formed from orthophosphates in biological treatment processes or by receiving water biota.

ANALYSIS

Phosphorus analysis embodies two general procedural steps: (a) conversion of the phosphorus form of interest to dissolved orthophosphate, and (b) colorimetric determination of dissolved orthophosphate.

Phosphates that respond to colorimetric analysis without preliminary hydrolysis of oxidative digestion of the sample are termed “reactive phosphorus.” While reactive phosphorus is largely a measure of orthophosphate, a small fraction of any condensed phosphate present usually is hydrolyzed unavoidably in the procedure.

Acid hydrolysis at boiling-water temperature converts condensed phosphates to orthophosphate. The hydrolysis unavoidably releases some phosphate from organic compounds, but this may be avoided by careful selection of acid strength, hydrolysis time and temperature. The term “acid-hydrolyzable phosphorus” is preferred over “condensed phosphate” for this fraction.

The phosphate fractions that are converted to orthophosphate only by oxidation destruction of the organic matter present are considered “organic” or “organically bound” phosphorus.

The total phosphorus may be divided analytically into the three chemical types that have been described: reactive, acid-hydrolyzable, and organic phosphorus. The figure below shows the steps for analysis of individual phosphorus fractions.
Appendix A

To calculate the three states of phosphorus in the sample, follow the procedures and calculations vertically in each block.

<table>
<thead>
<tr>
<th>Direct colorimetry</th>
<th>1. ( \text{H}_2\text{SO}_4 ) hydrolysis</th>
<th>1. Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Colorimetry</td>
<td>2. Colorimetry</td>
</tr>
</tbody>
</table>

\[ A = \text{Total reactive phosphorus} \]

\[ A+B \]

\[ C = \text{Total phosphorus} \]

\[ (A+B)-A \]

\[ C-(A+B) \]

\[ B=\text{Total acid-hydrolyzable phosphorus} \]

\[ D=\text{Total organic phosphorus} \]

TO PREVENT PHOSPHATE CONTAMINATION AND ADSORPTION OF PHOSPHATE ONTO TILE EQUIPMENT RINSE ALL GLASS CONTAINERS WITH HOT DILUTE HCL THEN RINSE SEVERAL TIMES IN dl WATER NEVER USE COMMERCIAL DETERGENTS CONTAINING PHOSPHATE FOR CLEANING GLASSWARE USED IN PHOSPHATE ANALYSIS

DAY 1: PERSULFATE DIGESTION

BACKGROUND: Because phosphorus may occur in combination with organic matter, a digestion method to determine total phosphorus must be able to oxidize organic matter effectively to release phosphorus as orthophosphate.

REAGENTS: 50 mg/L stock phosphate solution; phenolphthalein; \( \text{H}_2\text{SO}_4 \) solution; \((\text{NH}_4)_2\text{S}_2\text{O}_8\); \(1\) N NaOH; Unknown water sample; dilute HCl

APPARATUS: hot plates (4); glass dropper; beakers, acid washed (7); volumetric flasks, 100 ml, acid washed (7); volumetric flasks, 500 ml, acid washed (5); glass funnel, acid washed

PROCEDURE

1. Make sure beakers and 500 ml volumetric flasks have been acid washed. If not, wash in hot dilute HCl and rinse well with distilled water containing no phosphate.

2. Make up standard phosphate solutions in the 500 ml volumetric flasks. Calculate the correct amount of stock phosphate solution to use and dilute up with dl water. Standard solutions should be 0.25 mg/L, 0.50 mg/L, 1.00 mg/L, 2.50 mg/L, 5.00 mg/L. If you can not use a large enough volume of stock solution, you may have to use your high concentration standard solution.
3. Transfer exactly 100 ml of the unknown water sample to an acid-washed beaker. Transfer exactly 100 mls of each standard phosphate solution to separate acid-washed beakers. For a blank—put 100 ml of phosphate free dl water in an acid-washed beaker.

4. Add 2 drops of phenolphthalein to each beaker.

5. If a red color develops in a beaker, add H$_2$SO$_4$ solution dropwise to just discharge the color.

6. Add 2 ml H$_2$SO$_4$ solution and 0.8 g solid (NH$_4$)$_2$S$_2$O$_8$ to each beaker.

7. Boil each beaker gently on a preheated hot plate for 50-60 mm. or until a final volume of 20 ml is reached. Organophosphorus compounds such as AMP may require as much as 1.5-2 hr for complete digestion.

7a. **WHILE THE SOLUTIONS ARE BOILING ACID WASH EACH OF THE 100 ML VOLUMETRIC FLASKS IN HOT DILUTE HCI AND RINSE WELL WITH dl WATER**

8. For each beaker, cool, then dilute to 60 ml with dl water.

9. For each beaker add 2 drops phenolphthalein and neutralize to a faint pink color with 1 N NaOH.

10. Transfer each solution with an acid washed glass funnel into a properly labeled acid-washed 100 ml volumetric flask, and dilute to the mark. Stopper with acid washed glass stopper.

11. Make sure all hot plates are cleaned before putting away. Make sure beakers and glass funnel are rinsed well with dl water and acid-washed for use on Day 2.

**DAY 2: ACID HYDROLYSIS**

**BACKGROUND:** The acid-hydrolyzable phosphate content of the sample is defined as the difference between reactive phosphorous as measured in the untreated sample and phosphate found after mild acid hydrolysis. Generally, it includes condensed phosphates such as pyro-, tripoly-, and higher molecular weight species such as hexametaphosphate.

**REAGENTS:** standard phosphate solutions; phenolphthalein; strong acid solution; 6 N NaOH

Unknown water sample; dilute HC1

**APPARATUS:** hot plates (4); glass dropper, beakers, acid washed (7); volumetric flasks, 100 ml, acid washed (7); glass funnel, acid washed
PROCEDURE

1. Transfer exactly 100 ml of the unknown water sample to an acid-washed beaker. Transfer exactly 100 mls of each standard phosphate solution to separate acid-washed beakers. For a blank, put 100 ml of phosphate free dl water in an acid-washed beaker.

2. Add 2 drops of phenolphthalein to each beaker.

3. If a red color develops in a beaker, add strong acid solution dropwise to just discharge the color.

4. Add 1 ml strong acid solution to each beaker.

5. Boil each beaker gently on a preheated hotplate for 90 min., adding enough dl water to keep the volume between 25 and 50 ml.

6. WHILE THE SOLUTIONS ARE BOILING ACID WASH EACH OF THE 100 ML VOLUMETRIC FLASKS IN HOT DILUTE HCl AND RINSE WELL WITH dl WATER

7. Let each beaker cool.

8. Neutralize each beaker to a faint pink color with 6 N NaOH.

9. Transfer each solution with an acid washed glass funnel into a properly labeled acid-washed 100 ml volumetric flask, and dilute to the mark. Stopper with acid washed glass stopper.

10. Make sure all hot plates are cleaned before putting away. Make sure beakers and glass funnel are rinsed well with dl water and acid-washed for use on Day 3.

DAY 3: PHOSPHOROUS ANALYSIS (ASCORBIC ACID METHOD)- SPEC 20

BACKGROUND: Ammonium molybdate and potassium antimonyl tartrate react in acid medium with orthophosphate to form a heteropoly acid - phosphomolybdic acid - that is reduced to intensely colored molybdenum blue by ascorbic acid.

REAGENTS: standard phosphate solutions; unknown phosphate solution; persulfate digested samples; acid hydrolyzed samples; 5 N H₂SO₄ potassium antimonyl tartrate solution; ammonium molybdate solution; ascorbic acid solution, 0.01 M phenolphthalein; dilute HC1 solution

APPARATUS: Spectronic 20 with IR bulb set to 880 nm; Minimum of 7 cuvettes; glass dropper; 500 ml acid washed Erlenmeyer flask; acid washed beakers (7)
PROCEDURE

1. Let Spec 20 warm up. Set wavelength to 880 nm and calibrate according to manufacturers instructions. Make sure cuvettes have been cleaned of dirt and fingerprints with Kim-wipes.

2. Prepare color reagent in acid washed 500 ml Erlenmeyer flask. Mix the above reagents in the following proportions for 350 ml of the color reagent: 175 ml 5 N H$_2$SO$_4$, 17.5 ml potassium antimonyl tartrate solution, 52.5 ml ammonium molybdate solution, and 105 mls ascorbic acid solution. MIX AFTER ADDITION OF EACH REAGENT. Reagents must be at room temperature before they are mixed— and must be mixed in the order given. If turbidity forms in the color reagent, shake and let stand for a few minutes until turbidity disappears before proceeding.

THE REAGENT IS STABLE FOR 4 HOURS.

3. For each of the following 7 samples follow the procedure below: unknown solution; blank (dl water); 0.25 mg/L, 0.50 mg/L, 1.0 mg/L, 2.5 mg/L and 5.0 mg/L standard phosphate solutions.

   A. Pipet 25 ml of sample into clean, dry, acid washed beaker.

   B. Add 1 drop phenolphthalein. If a red color develops add 5 N H$_2$SO$_4$ dropwise to just discharge the color.

   C. Add 4.0 ml color reagent and mix thoroughly.

   D. After 10 min. but no more than 30 mm., transfer to a cuvette and measure absorbance of each sample at 880 nm, using reagent blank as the reference solution.

4. Repeat step 3 for the persulfate digestion samples. Repeat step 3 for the acid hydrolysis samples.

REPORT

1. For each of the three experiments prepare a calibration curve from the blank and 5 standard solutions. Plot absorbance vs. phosphate concentration to give a straight line passing through the origin.

2. Plot the appropriate unknown sample on the appropriate calibration curve to determine the concentration.

3. Determine the total phosphorous concentration, total reactive phosphorus concentration, total acid-hydrolyzable concentration, and total organic phosphorous concentration of the unknown solution.
Appendix 2

TRACE METAL ANALYSIS

DAY 1: SOIL COLLECTION AND PROCESSING

MATERIALS: PVC corer; aluminum foil; ruler; knife

METHOD

1. Find an appropriate area on the river and take a core sample.
2. Wrap the sample in aluminum foil.
3. Return to lab.
4. Cut soil into 4 cm sections and place on separate pieces of aluminum foil labeled appropriately. (e.g., 0-4 cm from surface, 4-8 cm from surface).
5. Let air dry covered in an appropriate location.

DAY 2: SOIL DIGESTION

MATERIALS: mortar and pestle; 2mm sieve; 100 ml beakers; 250 ml beakers (4); watch glasses (4); hot plates (2); Whatman No.41 filter paper (or equivalent); spatulas; dl water; concentrated nitric acid; concentrated HCl; hydrogen peroxide (30 %); 1:1 HNO₃:H₂O (v/v); 100 ml volumetric flasks (20); dl water containing 5 %HCl and 5 %HNO₃ Cu, Pb and Zn standard solutions (1000 mg/L); gloves

METHOD

1. Grind the soil sample in the mortar and pestle.
2. Sift the soil sample through a 2mm sieve into a 100 ml beaker to remove rocks and leaves.
3. Mix the sample thoroughly to achieve homogeneity. Weigh to the nearest 0.01 g a 2.00 g portion of the sample and put into the 250 ml beaker. Repeat with two more portions.
4. In a 4th beaker place a similar amount of dl water. Mark all 4 beakers at the 5 ml level for later use.
5. To all four beakers add 10 ml of 1:1 HNO₃, mix the slurry, and cover with a watch glass.
6. Heat the sample on a hot plate to 95 °C and reflux for 10 to 15 minutes WITHOUT BOILING.
7. Allow the sample to cool, then add 5 ml of concentrated HNO₃, replace the watch glass, and reflux for 30 minutes.
8. Repeat step 7.

9. Allow the solution to evaporate to 5 ml without boiling while maintaining a covering of solution over the bottom of the beaker.

10. Allow the sample to cool.

11. Add 2 ml dl water and 3 ml of 30 % \( \text{H}_2\text{O}_2 \). Cover with a watch glass and return to the hot plate to start the peroxide reaction. CARE MUST BE TAKEN TO ENSURE THAT LOSSES DO NOT OCCUR DUE TO EXCESSIVELY VIGOROUS EFFERVESCENCE. Heat until effervescence subsides and cool the beaker.

12. Continue to add 30 % \( \text{H}_2\text{O}_2 \) in 1 ml aliquots with warming until the effervescence is minimal, the general sample appearance is unchanged, or you have added a total of 10 ml (including the 3 ml from step 11).

13. Add 5 ml of concentrated HCl and 10 ml of dl water, cover with a watch glass, return to the hot plate, and reflux for 15 minutes without boiling.

14. Allow to cool, then pour through Whatman no.41 filter paper into a 100 ml volumetric flask.

15. Wash the filter paper 3 times with small portions of dl water. Make sure you stir the soil to get any trapped metals free into the liquid. Make sure you don’t use too much water to fill the volumetric.

16. Dilute the solution in the volumetric flask to 100 ml with dl water.

*************** ******************* ******************* ***************

WHILE WAITING TO COMPLETE STEPS ABOVE PREPARE YOUR STANDARDS BY THE FOLLOWING METHOD.

1. Determine the amount needed to prepare standard solutions of the following concentrations: 0.1, 0.5, 1.0, 3.0 and 5.0 mg/L.

2. Put the correct amount of Cu, Zn or Pb standard solutions into the correctly labeled 100 ml volumetric flasks.

3. Dilute to the mark with the dl water solution containing 5%HCl and 5%HNO₃.

4. Make a 0 mg/L standard solution with the dl water solution containing 5 % HC1 and 5 % HNO₃ in a 100 mL volumetric flask

*************** ******************* ******************* ***************
DAY 3: ATOMIC ABSORPTION SPECTROSCOPY ANALYSIS

MATERIALS: AA; 16 standard solutions; 3 sample solutions; 1 blank solution; dl water

INSTRUMENT PARAMETERS

Cu, Zn, Pb hollow cathode lamps
Fuel: Acetylene
Oxidant: Air
Type of flame: Oxidizing (fuel lean)
Wavelengths: Cu, 324.7 nm; Pb, 217.0 nm; Zn, 213.9 nm

ANALYSIS

For Cu - Analyze standards (lowest to highest), then blank, then samples. Record absorption for all.

Repeat for Pb and Zn.

RESULTS

Make a standard curve, absorption vs. concentration, with graph paper or linear regression for each element analyzed. From the standard curve calculate the concentration of metals in the digestates and then determine the contents of metal in sediment. Make sure you determine error ranges.
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IMPROVING SCIENCE EDUCATION IN THE UW CENTERS:
WORKSHOPS FOR SCIENCE FACULTY

NARRATIVE

I. INTRODUCTION

This proposal seeks to establish a coalition between the University of Wisconsin Centers, which is a two—year institution, and two four—year institutions: the University of Wisconsin—Eau Claire and the University of Wisconsin—Green Bay. The primary objective of the Coalition is to help the two—year faculty learn of new advances in their disciplines, and to help them plan ways to incorporate these developments into their classes. Coalition activities will include summer workshops and follow—up activities during the academic year. The Coalition will also bring together the two— and four—year faculty in on—going collaborative research.

The Context: a Two-Year College with Small; Widely-Dispersed Campuses. The University of Wisconsin Centers (UWC) is a public, multi—campus, two—year institution which offers freshman— and sophomore—level liberal arts courses to approximately 11,000 students yearly (see brochure Appendix A). The UWC has thirteen campuses located in small and medium size cities throughout the state, and a central office in Madison (see map Appendix B). The thirteen UWC campuses range in size of enrollment from UW Center—Richland, with 436 students, to UW Center—Waukesha County, with 2136. The UWC’s academic departments are organized as they would be if the institution were single—sited, i.e. in each discipline there is a single department whose faculty members teach on different campuses. All thirteen campuses offer courses from a common curriculum. The UWC is one of fifteen institutions of the University of Wisconsin System, which is responsible for all public higher education in the State.

The Problem: Scientific and Professional Isolation. Like good science teachers everywhere, the UWC science faculty wish to convey the latest developments in science to their students, and wish to give their students a sense of the excitement of science as a dynamic, ever—growing body of knowledge. But several obstacles make it difficult for the faculty to stay abreast of current developments in their field, and to maintain a sense of enthusiasm about incorporating new developments into their teaching. First, full—time science faculty at the UWC typically carry a 12—credit teaching responsibility. Second, laboratory facilities are so modest that faculty cannot realistically conduct research in them. Third, and perhaps most important, is the professional isolation which UWC science faculty experience as a result of the institution’s size, geography, history, and budget. Faculty experience disciplinary isolation because they work at relatively small, widely—dispersed campuses. Individual faculty often constitute a “department—of—one” on their campus, and have few opportunities for interaction with their peers on the other UWC campuses. The once— or twice—yearly departmental meetings are often the only time faculty meet with their departmental colleagues. Constraints of both time and budget make it difficult for UWC faculty to attend national or regional conferences. UWC science faculty also have traditionally been isolated from the science faculty at the other UW System institutions. There currently is no mechanism to help UWC faculty establish working relationships with faculty on the baccalaureate or doctoral campuses. Newly hired faculty typically maintain ties with their thesis advisor, and perhaps with colleagues where they did post—doctoral work. But after a number of years, these ties become weak, and faculty members find themselves scientifically and professionally alone.

The Solution: Forging an Alliance with the State’s Baccalaureate Campuses. In an attempt to find a solution to these problems, the UWC science faculty have been talking with each other and...
with the science faculty at other UW System institutions. In these discussions it was agreed that more interaction and collaboration between science faculty at the UWC and on the other UW System campuses would be helpful to all parties. The UWC faculty would benefit by exposure to faculty who are actively engaged in research. Faculty on the baccalaureate campuses would benefit from the experience that UWC faculty have in teaching exclusively freshmen and sophomores.

These discussions have led to a decision to establish a Wisconsin Coalition for the Improvement of Freshman and Sophomore Science Education. Initial members of the Coalition are the UWC, the University of Wisconsin—Eau Claire, and the University of Wisconsin—Green Bay. Other UW System campuses have expressed an interest in joining the Coalition, and could be incorporated in the future. The primary goal of the Coalition is to provide professional development opportunities for UWC faculty members. The Coalition will sponsor summer workshops and follow-up activities during the academic year. The purpose of these activities will be to bring UWC science faculty up to date on developments in their fields, and to discuss the best way to incorporate these developments into the teaching of freshmen and sophomores. Presenters will be teams of faculty from the baccalaureate campuses and the UWC. The Coalition will also serve as a clearing-house for information which will enable UWC faculty to establish working relationships with research-active faculty on the participating baccalaureate campuses. This is seen as a way to counter professional isolation for the UWC faculty.

II. PRELIMINARY WORK

Initial Discussions. In the summer of 1992, three UWC science faculty members (Janice Alexander, Assistant Professor of Chemistry; Catherine Helgeland, Assistant Professor of Geology; and Paul Martino, Assistant Professor of Chemistry) were chosen to participate in a three week workshop funded by the National Science Foundation Undergraduate Faculty Enhancement program, and sponsored by the Great Lakes Research Consortium at SUNY—Oswego, New York. The workshop focused on environmental problem solving as an effective teaching strategy to stimulate undergraduates interest in environmental science. The three found the workshop to be intellectually and scientifically exciting, and they returned with many ideas about how to introduce new material into their classes. At their departmental meetings that August, they shared some of what they learned with their colleagues, who were favorably impressed with the value of the workshop. When they sought other such professional development activities, they discovered that there are a few summer programs in the state, but they are not geared to the needs of two—year college faculty. In view of the great resources that are available in higher education in the State of Wisconsin, the UWC science faculty decided to forge a sort of alliance with the science faculty on the four—year campuses, and create professional development activities out of that alliance. The faculty became aware of the NSF—UFE Coalitions program, and decided to look there for funding for the pilot phase.

The Fall Conference. In response to these faculty concerns, UWC Chancellor Lee Grugel convened a conference on September 18, to begin planning for a science coalition (see conference program, Appendix C). Speakers included Katharine Lyall, the President of the UW System, Dr. Elizabeth Teles of the National Science Foundation, and Dr. Earl Peace, Senior Academic Planner for the UW System. Participants included 24 science faculty from the UWC and 24 faculty from 8 other UW System institutions. The participants showed a great deal of enthusiasm for the idea of forming a coalition, and most responded to a questionnaire about what workshops they would be interested in presenting or attending. With the questionnaire results in hand, Janice Alexander and Paul Martino initiated a series of conference calls with science faculty at several of the four-year campuses, to narrow down the potential workshop topics and participants.
The Spring Survey. Early in March, Alexander and Martino sent a survey to all UWC faculty members in biology, chemistry, geology, and engineering (n=61), asking their level of interest in several possible workshop topics (see survey Appendix D). The results indicated that there was strong interest in two topics: environmental science and teaching methods. The decision was made to offer an environmental science workshop at the University of Wisconsin-Green Bay, in the northeast part of the state, and a teaching methods workshop at the University of Wisconsin—Eau Claire, in the northwest part of the state. This decision was based primarily on the specific strengths of the two institutions. It was also based on geography such that most UWC faculty members are close to a site.

Descriptions of Participating Institutions.

The mission of the University of Wisconsin Centers is to provide students with the courses they need to transfer to a baccalaureate institution. (There are no vocational or technical courses offered; the state has a separate system for vocational—technical education.) The UWC grants the Associate of Arts and Science degree, which is accepted by all University of Wisconsin institutions as fulfilling the university—wide, college, and school general education breadth requirements. In the physical and natural sciences, courses are offered in biology, botany, chemistry, computer science, engineering, geology, physics, physiology, and zoology. Course articulation agreements are maintained with all the other campuses in the UW System.

With the least restrictive admissions requirements and the lowest tuition of any UW System institution, the UWC provides a window of opportunity for many people around the state who would otherwise find it difficult or impossible to begin their postsecondary education. Approximately 65% of UWC students are “first generation” college students, meaning their parents did not attend college. About one third of UWC students are age 25 or older. Fifty-five percent are female and 4% are minority.

The UWC combines access with high quality academic programming. The two-year retention rate for the fall cohort of 1987 was 48.1%, a rate which compares favorably with figures reported by Vincent Tinto, who finds that only 27 percent of all those who enter a two-year institution are retained for two years. UWC students do well after transfer. Among all those who began at the UWC as new freshmen in the Fall of 1980, 31.7% had received a bachelor’s degree by spring 1990. Among those who transferred to a four-year UW institution, 69.8 percent had received a bachelor’s degree by the spring of 1990. These figures probably underestimate the true number of bachelor’s degrees, as we are unable to gather data on students who leave the UWC and enroll at either a technical college or a four—year college other than the campuses in the University of Wisconsin System.


3 Concord and Presley, op. cit. “Outcomes of New Freshman Students.”

4 Ibid.

Over 85 percent of our instructional positions are held by regular faculty; there are no teaching
assistants. Temporary or part—time staff account for less than 15 percent of instruction, well below the Carnegie Foundation recommendation of 20 percent. Among the tenured or tenure-track science faculty, most hold the terminal degree in their discipline. In biology, 23 of the 29 faculty members have a doctorate; the figures for chemistry are 13 of 21, for physics 8 of 13, for geology 2 of 4, for engineering 3 of 3. The science faculty are heavily “tenured—in”: in biology 26 of the 29 faculty members are tenured; in chemistry the numbers are 17 of 21, in physics 11 of 13, in geology 2 of 4, and in engineering 2 of 3. Although the science faculty have not been grant—active in the past, there are signs that is changing: in the past five years we have had a National Science Foundation research grant in mathematics, and five NSF Instrumentation and Laboratory Improvement grants.

The University of Wisconsin—Eau Claire enrolls approximately 10,500 students, including over 500 graduate students, who are serviced by a faculty and staff numbering over 700. The UW-EC offers science course work through the Master’s degree in biology, communicative disorders, environmental and public health, and medical technology. The Graduate Faculty consists of over 300 faculty and academic staff who hold doctoral or appropriate terminal degrees, and who possess a broad array of special qualifications and backgrounds in their academic specialties.

The UW-EC has particular strength in recruiting and retaining students in chemistry. Currently, 154 students are majoring in chemistry or a chemistry—related field at UW-EC; 40% of these students are female. These figures compare very favorably with those of chemistry departments at many much larger universities. The UW-EC chemistry program is a case study in Sheila Tobias’ new book “Revitalizing Undergraduate Science: Why Some Things Work and Most Things Don’t.” The department’s ability to attract first—generation college students is impressive, particularly in the face of statistical evidence that shows that even scientists’ children eschew science,” Tobias writes. Since the first chemistry degree was earned at UW-EC in 1957, more than 500 students have completed the traditional chemistry major. Acting department chairman Robert Eierman says approximately 40% have gone on to earn advanced degrees, and the university ranks among the nation’s top five public undergraduate institutions for the production of chemistry grads who have earned Ph.Ds, with 96.

The University of Wisconsin—Green Bay enrolls approximately 5,000 undergraduate students and 230 graduate students yearly, and offers the Bachelor of Science and Master of Science degrees. Ninety-five percent of the faculty hold the terminal degree in their discipline. At its inception, UW-GB was designated as one of two “special mission” campuses within the UW System. Among several distinguishing objectives, the University was directed to “...offer programs employing a problem—focused approach, including an emphasis on regional, national and global environmental issues, and encourage innovative teaching in support of that approach.” In its efforts to reach this objective, the university developed an innovative major and minor in Environmental Science. This interdisciplinary, problem—focused program is unique in Wisconsin and has successfully combined instruction and research in its efforts to prepare students for productive careers in science.

Course work in the Environmental Science program emphasizes scientific principles which govern natural processes and which underlie the nature of environmental change. Students who major in Environmental Science select one of two emphasis areas: Ecology and Biological Resources Management or Physical Resource Management. Ecological concepts are the basis of much of the course work in the Ecology and Biological Resource Management emphasis area. These concepts provide the means for developing an integrated approach to resource management, an approach which is increasingly recognized as the direction of the future. The focus of the Physical Resources Management emphasis area is the conservation and
environmental quality of our physical resources: air, water, and soils. This emphasis area is especially appropriate for those who are interested in waste management and the recycling of society’s waste materials.

The Environmental Science program has always made concerted efforts to tie its educational programming and research efforts to the needs of the community and the region and to involve undergraduate students in research activities. In the sciences, student participation in research comprises one of the most important and effective means of learning. At UW-GB, the Environmental Science program has consistently provided numerous opportunities for its students to learn through participation in cooperative research projects with faculty members.

The UW-GB is well situated to be a leader in environmental education and research. The Green Bay area has a large and stable industrial base, consisting largely of pulp and paper industries, power generation, and food processing. Northeastern Wisconsin has the largest concentration of paper industries in the world. There is a natural fit between these industries and UW-GB’s focus on environmental education and research. Waste management and resource recovery are significant concerns in a state which already recycles 1.3 million tons of waste paper annually. As part of Lake Michigan, the bay of Green Bay is the largest freshwater estuary in North America and is heavily impacted by the residuals from these industries as well as non-point pollution sources. UW-GB’s Environmental Science Program provides students with unique educational and research experiences that offer multiple perspectives on the major environmental issues facing the region and the world.

All three institutions are accredited by the North Central Association of Colleges and Schools. It should also be pointed out that the UW System, of which these three institutions are a part, is very active in science education. Just one example is the UW System Women’s Studies Consortium, which is currently administering a five—semester, National Science Foundation—funded program called “Women and Science.” The goal is to address the under—representation of women and minorities in science and engineering. The program seeks to reach students who, though qualified to do science, choose another major. There are many other examples of innovation in science education within the UW System.

III. PROJECT DESCRIPTION

A. Coalition Activities

The Coalition will sponsor two summer workshops and follow—up activities during the academic year, as described below. All Coalition activities are designed to meet the following objectives: 1) to expose the faculty participants to new material in their disciplines; 2) to expose the faculty participants to innovations in science education; and 3) to help the two— and four—year college faculty make connections with each other - connections which will lead to collaborative research or other professional undertakings.

1. Summer Workshops

We plan to hold two week—long workshops, one on Teaching College Science at the UW—Eau Claire, and one on Environmental Science at the UW—Green Bay. Both will be inter—disciplinary, including material relevant to faculty in biology, chemistry, geology, and
engineering. The workshop on Teaching College Science will also include material relevant to faculty in Physics, and will include discipline-specific break-out sessions. The workshops will be team-taught; at each one, the presenters will be from at least two disciplines and from the two campuses involved. The workshops will be very interactive; we believe that the participants have much to share with and learn from each other.

Selection of Participants. After the notice of grant award from NSF, the Project Director will publicize the grant and the participation opportunities available. An article will be placed in the campus publication most widely read by faculty (CenterScope for the UW Centers, The University Bulletin for the UW—Eau Claire, and The Log for the UW—Green Bay). A flyer announcing the grant will be placed on the “grants bulletin board” of each campus. A special notice will be sent to department chairs, who will be asked to circulate the information to their faculty members, and encourage them to apply. Chairs will be asked to particularly target and encourage faculty who have not recently been professionally active. At the UW Centers, each eligible person in a relevant department will be sent an individual notice. (We have learned that communication across thirteen campuses is difficult, and requires this personal touch.)

Final selection of participants will be made by two committees, one for each workshop. The committees will consist of the Project Director and the workshop leaders. Participants will be chosen from faculty on the thirteen two-year campuses, and the two baccalaureate campuses. Thus the participants should span the length and breadth of the State of Wisconsin. We plan to include both two- and four-year faculty because one important goal of the project is to get the two- and four-year faculty involved in collaborative research activities. There will not necessarily be equal numbers of participants from the two institutions; every effort will be made to accommodate UW Centers faculty, who are the primary target of this proposal.

The intended audience for the project are those faculty who wish to improve the way they teach science to freshmen and sophomores. Participants will be asked to write a brief (no more than one page) essay describing their background and why they are interested in pursuing the workshop topic. The selection committees will attempt to select those who have the capability and desire to share newly acquired knowledge and techniques with other teachers of undergraduate students. Participants must agree to participate in the academic year follow-up activities and the summer 1995 reunion. Preference will be given to those who received their highest degree a minimum of five years before the start of the project, women, persons with disabilities, and under-represented minorities.

a. Teaching College Science: Issues and Methods

Workshop Content. The purpose of this workshop is to bring college science educators together to raise issues associated with teaching science, and to work cooperatively to understand and develop teaching methods that address those issues. The workshop will be five days in duration and there will be 30 participants who are faculty from chemistry, biology, geology, physics, and engineering sciences from both the UW Centers and the UW—Eau Claire. A team of four UW faculty (two from UW Centers and two from UW—Eau Claire) will act as facilitators. Since the participants and facilitators are all educators, the course will be run in an interactive mode to allow everyone’s voice to be heard. The sessions will be informal with ample opportunity for all to contribute their knowledge. In addition, efforts will be made to give the individuals chances to interact in social and recreational settings.

Sessions during the first several days will emphasize teaching issues found in all science disciplines. This will allow the whole group to work together to understand learning and teaching issues and processes. Subsequently they will interact to comprehend and devise strategies to
teach more effectively. Issues such as learning theory, levels of cognitive development, active lecturing, teaching problem solving, critical thinking, and cooperative learning will be addressed. Cooperative group structures will be used to increase participation and encourage individuals to make contacts with each other. Some teaching methods will be modeled during the sessions with the participants acting as students. In addition, an outside expert or two will be brought in to present some aspects of science education (e.g. Dr. Karl Smith of the University of Minnesota on cooperative teaching methods as a keynote speaker, Earl Peace of the UW System as a presenter). Procedures for assessing the impact of changes in teaching methods on the achievement and attitudes of students will be discussed, too.

As the week progresses, content issues will be brought into the discussions. Some of these will be general science issues, such as uncertainty in science and authority analysis, to be discussed with the entire group. It is also planned to split into discipline—specific groups to allow issues and solutions specific to teaching chemistry, biology, or other disciplines to be raised and discussed. This will also allow individuals in specific disciplines to get to know one another better. Creation of a network of participants is an important workshop goal.

The participants will be expected to implement some of the ideas or methods in their teaching during the next school year. The last day will be spent facilitating the planning process for that implementation. Participants will be grouped according to their interests to discuss the change they intend to try and the methods they’ll use to assess the impact of the changes. It may be possible to devise projects that involve groups of teachers. Information will be provided to enable participants to stay in touch following the workshop to allow them to support each other during the subsequent teaching activities. The goal will be that each participant will have a well developed plan of a new teaching method or strategy that they will try during the next school year, and a way of assessing the effect of that change. Participants will return to Eau Claire in 1995 to report the results of their project.

**Workshop Presenters.** Presenters will include Robert Eierman, Professor of Chemistry, UW-Eau Claire; Wilson Taylor, Professor of Biology, UW-Eau Claire; John Albrecht, Assistant Professor of Chemistry, UW Center-Richland; Janet Phelps, Associate Professor of Biology, UW Center-Baraboo\Sauk; and Earl Peace, UW System Academic Planner.

**Workshop Logistics.** Participants from the UW Centers will car—pool from their campuses. One van or car (or as many as necessary to accommodate the number of travelers) from each campus will be provided by the UW Centers. The car will remain at the workshop site until participants drive back. Lodging will be in a dormitory on the UW—Eau Claire campus. Meals will be served in the dormitory cafeteria, except for a few special events such as a mid—week banquet with keynote speaker. Participants from the UW—Eau Claire will not need travel or lodging, but will participate in some special meals and recreational/social events.

**Workshop Schedule.**

TEACHING COLLEGE SCIENCE: ISSUES AND METHODS: An NSF-UFE Workshop

NOTE: Sessions will be interactive with leadership by the person named in parentheses.

**MONDAY**
8:00—9:00 Welcome, introductions and a group building exercise
9:00—10:00 Teaching issues of concern and teaching methods used presently
10:00—10:15 BREAK
10:15—12:00  Active lecturing (Dr. Eierman)
12:00—1:30  Lunch and leisure
1:30—3:30  Learning styles and appropriate teaching methods (Prof. Albrecht)
3:30—3:45  BREAK
3:45—5:00  Guaranteed student success (Dr. Phelps)
Evening  Optional informal get-together for recreation and refreshments

TUESDAY
8:00—10:00  Cognitive mapping (Prof. Albrecht)
10:00—10:15  BREAK
10:15—12:00  Communicating expectations (Dr. Phelps)
12:00—1:30  Lunch and Leisure
1:30—3:30  Laboratory teaching structures I (Dr. Eierman)
3:30—3:45  BREAK
3:45—5:00  Laboratory teaching structures II (Dr. Taylor)

WEDNESDAY  All day workshop on teaching methodology (Earl Peace)
5:30  Banquet with keynote speaker

THURSDAY
8:00—10:00  Biology (Drs. Taylor and Phelps) and Chemistry (Dr. Eierman and Prof. Albrecht)
Discipline—specific groups, other discipline-specific groups depending on the
make-up of the participants; lecture issues and methods
10:00—10:15  BREAK
10:15—12:00  Discipline-specific groups, laboratory issues and methods
12:00—1:30  Lunch and Leisure
1:30—3:30  Uncertainty as an integral part of science (Dr. Taylor)
3:30—3:45  BREAK
3:45—5:00  Assessing student achievement and attitude changes (Dr. Eierman)

FRIDAY
8:00—8:30  A teaching research project (Dr. Eierman)
8:30—10:30  Small-group discussion of possible teaching projects
10:30—10:45  BREAK
10:45—12:00  Teaching project interest groups with discussion of assessment
12:00—2:00  Lunch and time to prepare presentation of projects
2:00—3:30  Individuals describe proposed teaching and assessment project
3:30—4:00  Assessment of short course and farewell

b. Environmental Science Workshop

Workshop Content. The purpose of this workshop is to bring college science
educators together to some recent developments in environmental studies and their implications
for freshman—sophomore instruction. The workshop will be five days in duration and there will
be 30 participants who are faculty from chemistry, biology, geology, and engineering sciences
from both the UW Centers and the UW-Green Bay. A team of UW faculty from the UW Centers
and from UW-Green Bay will act as facilitators. UW-Green Bay faculty will be running the
majority of the workshop since we have been unable to find UW Centers faculty with the
expertise required. UW Centers faculty have extensive knowledge about teaching methods
(naturally), but genuinely do not have a lot of expertise in the environmental science area. This
accounts for the difference in staffing of the two workshops. UW Centers faculty are included in
the staffing so that they have a hand in designing the workshop to meet their needs. Since the
participants and facilitators are all educators, the course will be run in an interactive mode to
allow everyone’s voice to be heard. The sessions will be informal with ample opportunity for all to contribute their knowledge. In addition, efforts will be made to give the individuals chances to interact in social and recreational settings.

The session will begin with an overview of new developments in global environment, water resource preservation, and energy conservation. The field of environmental studies is advancing and expanding so rapidly that inclusion of all recent developments in a one—week seminar would be impossible, so the seminar will concentrate on a few important developments. The focus of the seminar will be problems and solutions for landfills and industrial waste sites. Discussions on this area will include: problems associated with landfills and industrial waste sites; biodegradation of organic waste; recovery of methane for fuel; industrial pollution management; and chemical analysis of inorganic and organic contaminants. Several afternoons will be spent in the laboratory instructing participants on new experimental techniques. Participants will take part in several laboratory exercises that are appropriate for subsequent freshman—sophomore involvement. The latter part of the seminar will focus on taking the acquired knowledge and skills back to home institutions. By the end of the seminar participants will be able to develop curricula and research projects at the freshman—sophomore level.

The participants will be expected to implement some of the ideas or methods in their teaching during the next school year. The last day will be spent discussing new developments in environmental science teaching methods followed by facilitation of the planning process for that implementation. Participants will be grouped according to their interests to discuss the change they intend to try and the methods they’ll use to assess the impact of the changes. It may be possible to devise projects that involve groups of teachers. Information will be provided to enable participants to stay in touch following the workshop to allow them to support each other during the subsequent teaching activities. The goal will be that each participant will have a well developed plan of a new teaching method or strategy that they will try during the next academic year, and a way of assessing the effect of that change. Participants will return to Green Bay in 1995 to report the results of their project.

_Workshop Presenters._ The environmental science workshop presenters will include James Wiersma and John Lyon, both Professors of Chemistry, UW-Green Bay; Leander Schwartz and Michael Morgan, both Professors of Biology, UW-Green Bay; Janice Alexander and Paul Martino, both Assistant Professors of Chemistry, UW Centers and a UW Centers biologist, yet to be named.

_Workshop Logistics:_ Participants from the UW Centers will car-pool from their campuses. One van or car (or as many as necessary to accommodate the number of travelers) from each campus will be provided by the UW Centers. The car will remain at the workshop site until participants drive back. Lodging will be in a dormitory on the UW-Green Bay campus. Meals will be served in the dormitory cafeteria, except for a few special events such as a mid—week banquet with keynote speaker. Participants from the UW-Green Bay will not need travel or lodging, but will participate in some special meals and recreational/social events.

_Workshop Schedule:

ENVIRONMENTAL SCIENCE WORKSHOP

MONDAY (Presenters are indicated in parenthesis)

MORNING: (Wiersma, Morgan)
Welcome, introductions, group discussion of what is currently being taught in the area of environmental studies and what the participants would like to see in the way of new methods. An introduction of new developments in global environment, water resource preservation, and energy conversion.

AFTERNOON: (Schwarz, Morgan)

An overview of the microbial ecosystem and environmental factors which affect the anaerobic degradation of organic wastes. Examination of the potential advantages of anaerobic treatment of liquid and solid waste including energy recovery from landfills. Biotic responses to global warming.

TUESDAY

MORNING: (Schwarz, geologist)

Field trip to the Outagamie County landfill to observe energy recovery by utilization of methane. Visit to industrial waste sites and sample collection.

AFTERNOON: (Schwarz, UW Centers biologist)

Monitoring of a functioning anaerobic reactor. Lab analysis by gas chromatography (GC) of glucose and fatty acids.

WEDNESDAY

MORNING: (Wiersma, Lyon)

Discussion sections on the environmental redox chemistry of nitrogen compounds in aerobic and anaerobic environments, methods for the analysis of heavy metals and pesticides, dealing with PCB’s and heavy metals in dredge spoil disposal.

AFTERNOON: (Wiersma, Lyon, Alexander, Martino)

Lab analysis of heavy metals and pesticides including GC—FID and high pressure liquid chromatography (HPLC).

THURSDAY

MORNING: (Nancy Sell — engineering)

General overview of industrial pollution and its control. Industrial pollution and its control for specific industries in Wisconsin.

AFTERNOON: (Wiersma, Lyon, Alexander, Martino)

Lab analysis of heavy metals and pesticides including GC—FID and HPLC.

EVENING: Banquet with keynote speaker.

FRIDAY
MORNING: (Morgan)
The teaching of environmental science.

AFTERNOON:

2. Follow—up Activities During the Academic Year
At the end of the fall Semester, each participant will send a 2—6 page report to the Project Director. The report will cover two topics: 1) what materials and ideas from the workshop the participant introduced into his or her classes, and with what result; and 2) whether the participant has begun any collaborative research or other professional activities with faculty on the other campus.

There will be a two weekend reunions, one in Eau Claire and one in Green Bay in May, 1995, at the conclusion of the academic year. Each participant will present a 20—25 minute summary (including 5—10 minutes for questions) of how they integrated what they took home from the workshop into their classes. Ideally, the talk will be illustrated with slides, transparencies or other AV aids. Each participant will also prepare a written summary (8 single spaced pages maximum, plus appended course materials) relating what they did, how the students responded, and what they will do differently the next time. Participants will also be asked to indicate whether they have begun any collaborative work or other professional activity with faculty from the other campus. All the participants’ materials will be assembled into one report, with a copy to each participant by the next fall.

B. The Setting: Facilities and Equipment Available
The UW—Eau Claire and the UW—Green Bay have all the facilities and equipment necessary for the project. The UW—Eau Claire has 26 modern buildings located on a 333— acre campus. There are extensive resources, including laboratories with the latest equipment, a planetarium, an observatory, greenhouses, theaters, exhibition centers, and a media development center. The UW—Green Bay has 12 major buildings on 700 acres. All buildings are connected by underground pathways which are very handicapped— accessible. The UW—GB has extensive resources, including a large arboretum which is used for recreation and research, and fully-equipped laboratories for biology, chemistry, computer science, and physics. The UW—GB recently received a grant to augment its molecular and biology laboratories through an NSF—ILL grant. Both the UW—Eau Claire and the UW—Green Bay maintain an intellectual setting conducive to learning by a group of mature professionals (especially in the summer, when there are relatively few undergraduates on campus!).

C. Project Administration. There will be one Project Director and one Project Co—Director who will do the organizational work necessary to the project. The other senior personnel listed on the budget page are workshop presenters. For a list of some of the tasks to be done, and the anticipated calendar for getting them done, see the Administrative Timetable (Appendix E). Careful supervision is required to coordinate people on 15 different campuses, to ensure that each workshop is organized to reach project objectives. The Project Director and Co—Director must also organize the summer 1995 reunion, and complete the evaluation during the summer of 1995. Both the Project Director and the Co—Director take a one quarter release in the spring semester 1994. Both will also devote at least two in the summer of 1994 to the workshops and the initial evaluations. They will both devote at least four weeks in the summer of 1995 for the reunion and the final evaluation.
Qualifications of Key Personnel. See Curriculum Vitae in Biographical Sketch.

Janice Alexander, the Project Director, has a doctorate in chemistry from the University of Virginia (1991) and has published in such journals as *Peptides* and the *Journal of Forensic Sciences*. She is Assistant Professor of Chemistry at the University of Wisconsin Centers—Fox Valley, where she teaches general chemistry and quantitative analysis.

Paul A. Martino, the Project Co—Director, has a doctorate in chemistry from the University of Virginia (1991) and has published in such journals as the *Journal of the American Society of Mass Spectrometry*. He is Assistant Professor of Chemistry at the University of Wisconsin Centers-Manitowoc, where he teaches general chemistry, organic chemistry, and biochemistry. He helped to develop these courses on his campus.

During the summer of 1992, Alexander and Martino participated in a 3-week workshop funded by the National Science Foundation Undergraduate Faculty Enhancement program, and sponsored by the Great Lakes Research Consortium at SUNY-Oswego, New York. The workshop focused on environmental problem solving as an effective teaching strategy to stimulate undergraduates’ interest in environmental science.