12

CONCORD EDUCATION FUND
GRANT PROPOSAL COVER SHEET

ACADEMIC YEAR 2002-2003 GRANTS

PROPOSAL TITLE Microscale Chemistry Laboratories

PROPOSAL APPLICANT NAMES
Gina Bergskaug, CCHS Science Dept.

PROPOSAL CONTACT

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GRADE LEVEL AND ESTIMATE OF NUMBER OF STUDENTS WHO WILL BENEFIT FROM THE PROPOSAL
10-12th grade chemistry students (95% of student population)

DESCRIPTION OF PROPOSAL
This proposal requests the funds necessary to equip the chemistry labs as microscale chemistry labs. Smaller equipment with increased precision is required.

TWENTY FIVE COPIES DUE NO LATER THAN 5:00 PM ON FEB. 1, 2002

PLEASE SUBMIT TO:

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Grant Proposal: Concord Education Fund (2002-2003)
Proposal Title: Microscale Chemistry Laboratories
Applicant: Gina Bergskaug, CCHS Science Department

A. Proposal Goal

As both a chemist and a teacher educated in the 1990's, I am in a constant struggle between what is exciting and attention grabbing and what is safe and harmless for the students. "The Boston Fire Department answers about a dozen calls a year from local school chemistry labs that experience fires or explosions (Yemma, 1998)." Is there a way I can make my chemistry classes simultaneously more effective and nontoxic, or is that an unattainable goal? According to the National Microscale Chemistry Center (NMC^2), "the best way to succeed in this effort is by eliminating chemical waste at the source."

Each year, more than three hundred students participate in the Concord-Carlisle High School chemistry program. If the school's two laboratories are fully equipped as Microscale Chemistry Laboratories, approximately ninety-five percent of the high school population could benefit from this safer system of experimentation. The standard and enriched levels would benefit from our conscious commitment to the NMC^2's principle of the 3R's (reduce, reuse, recycle). The honors and advanced placement levels would benefit from the exposure to the smaller quantities pharmaceutical researchers and other specialists have been using for years. The physically challenged would profit from participating in microscale work with more ease; for, small scale setups with microburets, microbeakers, and microspatulas are easier to carry and maneuver.

B. Proposal Description

During the 2001-2002 school year, the high school science department has made a renewed commitment to safety in the laboratories. We have implemented monthly safety discussions at our department meetings. I have attended a two-day Laboratory Safety Institute workshop with the intent of becoming the Chemical Hygiene Safety Officer of the School. This year, the high school has been awarded a $20,000 EPA grant that provides staff training and funds the clean out of dangerous and no longer needed chemicals. I will receive this training and will lead the clean out. By June 30, our chemistry labs should be clear of any excess chemicals and/or excessively hazardous chemicals. The 2002-2003 school year is the optimum time to transform our laboratories into microscale and green, or environmentally sound, chemistry labs. Microscale chemistry labs use miniature glassware, accessories, and reduced masses of chemicals to perform chemistry experiments. When working on this scale, it is important to maintain the precision of the instruments. So, the equipment needs to be more precise (usually ± 0.001) than macroscale equipment (often ± 1).

Microscale chemistry laboratories offer a plethora of advantages over macroscale labs (our current model). "Microscale chemistry is a laboratory-based, environmentally safe, pollution-prevention approach (Singh, 1999);" moreover, it is a cost effective and efficient program. The philosophy behind microscale chemistry is simple. If we cut our use to 1/1000, we cut our risks by the same amount.

In any laboratory, acid spills, rising plumes of putrid gases, and beakers bubbling over with potentially dangerous chemicals are practically a staple. If we reduced the mass of chemicals used in these reactions, the danger involved in each scenario decreases as well. The air quality in the laboratory improves drastically as a result of performing experiments on a smaller scale. Both student and teacher exposure to toxic chemicals decreases alongside the decrease in chemical mass. Any accident becomes much more manageable, as spills, fires, and explosions are easier to control when they occur on the microscale level. "Over the past six years of observation of microscale organic and inorganic laboratories, there have been no reports of accidents of this type received (Szafran, 1989)." When teachers treat the environment seriously, the students learn quickly by example.

"It is generally more expensive to dispose of inorganic...wastes than it is to purchase the chemicals themselves (Szafran, 1989)." By creating microscale chemistry labs, both chemical use and waste is reduced. This dramatically reduces the cost of the entire chemistry laboratory program; for, we would need a smaller mass of chemicals with which to experiment and we would have a corresponding reduction in waste.

Finally, microscale chemistry laboratories are more efficient. Required space for the proper storage of chemicals and microscale glassware is condensed considerably. In addition, experiment time can be reduced drastically. For example, a typical large-scale titration experiment requires just under one-half hour; however, one can complete six to ten titrations utilizing a microburet in the same amount of time without jeopardizing the

accuracy or the precision (Singh, 2000). This promotes a key idea in science research: multiple trials are required to achieve validity. Also, lab skills are improved after additional experiments have been conducted. The psychology of students using the chemicals changes, because they begin to learn a great deal of information without wasting an excessive amount of chemicals. In lab blocks where we often find ourselves "crammed" for time, microscale experiments allow for further analysis and thought about what is important: the chemistry. Time is not wasted on tedious set-ups and laborious clean-ups.

The adoption of microscale chemistry at he high school level is imperative to a safe and environmentally friendly laboratory. Not only have microscale chemistry labs proven to be safer, they are also more economical and effective. The need for such labs is evident. The source of funding for the new, more precise microscale laboratory equipment is our only hindrance.

C. Evaluation Methodology

The National Microscale Chemistry Center was established almost ten years ago to promote the use of Microscale chemistry to help reduce chemical waste. By reducing both use and waste, we are able to save money on two fronts. Therefore, it will be quite simple to evaluate the cost effectiveness over a given year. After Al Powers and I organized, inventoried, and catalogued the chemicals in the science department two years ago, the science department has been able to maintain a running tally of chemical use and ordering. After implementing the microscale techniques, I would monitor chemical use

and the resulting chemical waste created. I am confident we would see a dramatic change, as results from other schools suggest.

We intend to monitor the impact of the microscale program on student learning. The American Chemical Society has developed a national chemistry exam that will be given to all chemistry students at the end of the 2001-2002 school year. The same exam will be given to all chemistry students at the end of the 2002-2003 school year. This second group of students will have been engrossed in the Microscale Lab program. The results from both years will be analyzed to identify any statistically significant changes.

D. Proposal Budget

Although the high school could launch the program in simply one lab, I strongly believe the curriculum would be effective if implemented across the board in chemistry. Chemistry lab groups consist of two students working together for a total of twelve lab stations per lab. Therefore, we would need enough supplies to accommodate twenty-four lab groups. I have included an extra set of glassware for each lab to accommodate the following possibilities: broken equipment, a demonstration set, a prep set, or a possibly overcrowded section.

	Cost	Quantity needed	Total Cost
Electronic mg balance	$600	6	**$3600**
Automatic delivery pipet, 10-100 μL	$233	2	**$466**
Automatic delivery pipet, 100-1000 μL	$233	6	**$1398**
Magnetic stirring hotplates, 3"x3"	$330	24	**$7920**

Glassware, High School Microscale Kit	$130	26	**$3380**
Additional glassware (flasks, 10 and 50 mL beakers)	$107 (per 12)	2	**$214**
Microscale Clamp and bar	$24	50	**$1200**
Microburners	$30	26	**$780**
Microspatulas	$6	26	**$156**
96-hole well plates, rounded bottom	$2	26	**$52**
TOTAL			**$19,166**

E. Qualifications

In order to effectively implement the program, the facilitator must be trained. I participated in the 20 lab hour NMC^2 workshop for high school chemistry teachers November 13-15, 1998 and the 20 lab hour workshop for advanced techniques in high school April 6-8, 2001. These workshops were quite effective, as we actively participated in multiple laboratory experiments, lectures, and demonstrations. More specifically, the workshops included:

- A brief history of microscale chemistry and the NMC^2
- An introduction to microscale chemistry glassware
- Hands-on experience using the glassware and small quantitites
- More than ten laboratory experiments of our choosing
- A presentation of the effectiveness of the Microscale program in various institutions

The NMC^2 offers multiple week-long workshops over the summer that might prove to be integral in implementing this program easily into the high school. My previous

participation in some of the available workshops and my anticipated participation in an extended summer workshop would allow me to run training sessions for other CCHS chemistry teachers before the implementation of this program in September 2002. The NMC^2 encourages discussion both among workshop participants and between participants and the instructors. They have made themselves available for questions and troubleshooting as we attempt to implement the program in our own schools.

F. Conclusion

I am eager and enthusiastic to create two microscale chemistry laboratories at Concord-Carlisle High School. I strongly believe we have only one choice for the future of our chemistry program. The sooner we implement this new program, the better off we will all be. The microscale chemistry lab program has proven to be more environmentally safe, cost effective, and efficient program. This program will allow a broader and deeper coverage of the full curriculum. This is key in today's classroom as MCAS and heightened state standards require us to accomplish so much more than ever before. With the implementation of the microscale lab program, CCHS students will also become more conscientious citizens and leaders.

Resources

Singh, Mono M., *A Comparative study of microscale and standard burets: Journal of Chemical Education, vol 77, no. 5*: 2000.

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Szafran, Svi, *The microscale inorganic laboratory: safety, economy, and versatility, Journal of Chemical Education, vol. 66, no. 11*: 1989.

Yemmas, John, *The Right Chemistry, The Boston Globe*, April 5, 1998.