Chapter 10
Needs, Costs, and Accessibility of DE Science Lab Programs

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Introduction

The issue of how to deliver science labs at a distance goes back to distance education (DE) pioneers at the Open University (UK). In his book "The Open University," Walter Perry, first Vice-Chancellor of the Open University, described how he was often asked, "How are you possibly going to be able to teach science and technology, where laboratory work is a significant part of the total course?" His response was:

> I used to argue that we could teach the laboratory element of scientific disciplines in three ways. The first was by television where demonstrations of experiments can usually be carried out more efficiently than in the classroom... The second way in which we could approach laboratory teaching was by developing what we called a "home experiment kit" for each course where needed. This used to be laughed at, since for most people it conjured up the vision of sort of child's chemistry set. But what we actually designed over the years was very much more sophisticated than that. The third way

> in which we could provide laboratory experience was at summer school, where the whole week could be devoted to laboratory work… (Perry, 1976)

Perry's answer covers the essential possibilities for DE science laboratory programs. As he noted, one way to deal with the challenge is to make use of multimedia, for example videos of experiments. This can be extended to the host of interactive computer simulations that are available today. But when it comes to hands-on experimentation, the only options are home lab kits and concentrated residential laboratories, where students physically attend a lab session that lasts several days. Indeed, at Athabasca University, these are the two primary ways that students complete science laboratory work. Athabasca University's science program has been described previously (Kennepohl & Last, 1997).

However, there is no guidebook on how to implement a DE science laboratory program. There is virtually no common, shared knowledge among science academics and educators that enables us to implement such a program, which is very different from semestered, residential lab programs that almost all of us were trained in. One of the aims of this chapter is to share, at least in part, what it takes to run science labs at a distance. There are a number of requirements, in particular institutional supports, which can easily be overlooked.

The choice between home labs and on-site, supervised labs can be controversial. The whole purpose of home labs is to increase student accessibility, and we present data showing that home labs do this. At the same time, there are the persistent ideas that home labs are expensive to run (Ross & Scanlon, 1995) or that they impose a high development cost on instructors (Forinash & Wisman, 2001). We attempt to answer the question of cost through an actual costing of different laboratory delivery modes in general chemistry.

A. What is needed to run a DE science lab?

Core science lab staff

Athabasca University Science Lab's main purpose is to deliver an accessible, individualized, distance-delivered university level science lab education to all our science lab students. The Science Lab at Athabasca University has three full-time staff members who are responsible for laboratory coordination and logistical support, and provide information to students and academic staff for all science lab courses (biology, chemistry, physics, geology, and geography).

The Science Lab Coordinator's main role is to ensure the smooth and efficient delivery of home and residential supervised lab courses. This is accomplished by coordinating and developing teamwork between the course professor, lab instructors, the science lab staff, and other departments; to make the lab learning experience safe, enjoyable, and as educational as possible for the student. The Lab Coordinator is the primary contact for all science students who have questions about lab courses and experiments.

The Science Lab Technician is involved in lab kit design, construction, and maintenance, all of which involve finding technical solutions. For supervised labs, the Lab Technician prepares all the lab supplies. In addition, at AU, the Lab Technician is also the Lab Purchasing Officer, and therefore is responsible for ensuring that all the lab materials, reagents, and supplies are on site when the Science Lab Kit Manager needs them for kit restocking and maintenance, or for a residential DE supervised lab session.

The Lab Kit Technician has a very broad range of responsibilities. From the construction and restocking of kits, to the receiving and processing of lab kit requests, to maintaining a lab kit shipment database, the Lab Kit Manager is expected to ensure that lab kit standards are implemented and followed in all aspects. Technical ability is also required, as electronic equipment and other delicate kit components need to be frequently tested and repaired. The Lab Kit Manager must work closely with the Lab Technician, and the

Lab Coordinator, to make sure each science course professor is satisfied with the home lab component delivery for their course.

Home lab programs

Home lab kits can take from two to four years of design and planning, with kit prototypes often being sent to select students before mass kit construction begins. Logistics such as availability of critical supplies and best student outcomes must be considered during the development stage.

One of the key requirements in operating a home lab program is a dedicated laboratory space for the construction, packaging, refurbishing, and storage of the lab kits. The amount of space required is a function of the size of the kits, the nature of kit contents, and kit turnover — how many kits are in circulation, how long it takes to replenish and refurbish a kit, how fast kits are returned, etc.

There are significant coordination and communication functions required to operate a home lab program. Once a student has registered in a course with a home, the student will want to know more about the lab component, how to get their kit, and what to do with it. From the moment the student requests the home lab kit online until they receive, use, and return the kit, the laboratory staff try to communicate with the student as much as possible to make sure the student understands and knows what to do with the kit. The kit request, shipping, and return are tracked using an online kit records system.

Residential DE lab programs

DE residential lab sessions are frequently planned over one year in advance. This is partly due to student demand, so that students can do long-range planning of their science program. However, on the more practical side, it is necessary and prudent to book lab facilities well in advance, and prepare and post lab schedules online. In addition, logistical considerations play a role as to when supplies must be ordered and then eventually transported to the appropriate lab site. Lab instructors must also be contacted and contracted for their services.

The online student lab registration database serves as a hub of information and data for lab staff, professors, lab instructors, and students to conveniently find out when, where, and who will be attending a lab session. Lab contingency planning must be considered should a lab session have to be cancelled or moved. Finally, lab session debriefing among instructors and including student feedback help us plan and offer improved lab sessions on an ongoing basis.

Laboratory instructors

The laboratory instructors who supervise residential labs are critical to the student's laboratory experience. As such, they must be highly qualified in their discipline and have demonstrated teaching ability. Due to the intermittent nature of AU labs, lab instructors work under short-term contracts. Lab instructors often work as AU tutors on a part-time basis. Some lab instructors are graduate students studying at other universities. AU lab instruction contracts are particularly attractive to graduate students because of the good compensation and because labs are often run on weekends and are not disruptive to their graduate work. Further, AU lab instructors are not responsible for marking lab reports; marking is the responsibility of course tutors who are in contact with students throughout their course.

Residential lab sessions are usually scheduled to run for an 8–9 hour day, depending on the course. Because of the intensity, length, and nature of lab instruction, we use a minimum of two lab instructors for each session. Residential labs that run for 2–4 days require a high degree of organization and timing throughout the days in order to complete all of the experimental work. When one instructor is interacting with students, the other instructor is often preparing for the next experiment. Further, having two instructors provides the opportunity for breaks and gives flexibility when lab activities need to be altered unexpectedly.

Relations with external institutions

In several AU science courses, labs are offered using laboratory space at external institutions. This is always done at times when the laboratories are not being used, such as weekends, reading weeks, and spring/summer intersession periods. For the external institution, AU teaching labs provide a way to get something from underutilized space. In all cases, the usage agreements involve some sort of cash or in-kind payment for the use of laboratory facilities. Costs vary depending on the institution and the lab space being used. Typical costs are provided in the next section.

External publicly funded institutions that host AU laboratories also gain a degree of political advantage with government funding agencies because they are able to show their ability to cooperate with 'sister' institutions within the province.

At the present time, AU residential labs are only offered within the province of Alberta. This is partly because post-secondary education is within provincial, not federal, jurisdiction. If AU were to offer on-site educational programs, such as labs, in other provinces, it would potentially create an intergovernmental turf war arising from the competition of AU with public institutions that are funded by their home province. At the same time, however, other provinces have no way of preventing students from enrolling in the distance education courses and programs from outside their province.

One of the ways to get around this interprovincial barrier to running science laboratories in other provinces is informal partnerships with universities located there. For example, Athabasca University has an arrangement with McMaster University, in southern Ontario, whereby McMaster University offers residential organic chemistry labs over four days in the summer months when their facilities are not being used. These labs are operated entirely by McMaster and instructed by full-time McMaster staff. AU students pay a fee directly to McMaster to attend these labs. McMaster provides AU with pass/fail grades of students, and the students who pass are considered to have met the AU lab requirement. For many students located in southern Ontario, the cost to attend McMaster labs is significantly lower than the cost to travel to Alberta for AU residential labs. Just as in the residential lab arrangements with Alberta institutions, the out-of-province partner benefits from a revenue stream associated with little investment.

Institutional support

Distance delivered education requires a number of institutional services that go beyond the typical teaching-related activities that are part of the function of an academic department. For example, IT support is necessary for running an online laboratory booking service. Other institutional supports include facilities management, legal advice, financial services, library services, and shipping & receiving — a function that is crucial to home lab programs. The exact organization of these supporting activities is institution-dependent, but it is important that these supports are present when new distance delivered courses are introduced.

B. Full costs of DE lab programs

It has been suggested that laboratory programs based on home lab kits are significantly more expensive to develop and to operate than residential labs (Ross & Scanlon, 1995). We are unaware of any published work that quantifies the difference in cost, despite the obvious importance of the question to DE institutions. Decisions about laboratory programming must take into account the sustainability of any particular delivery mode for the laboratory component of a course. For this purpose, we present a full costing of different laboratory delivery modes, based on a first-year general chemistry in the North American system of three-credit, one-semester courses. Table 1 shows the estimated total costs of running the same general chemistry labs in different delivery formats.

Table 1. Per Student Costs of General Chemistry Labs in Different Delivery Modes*

	DELIVERY MODE		
Item	**On Campus, Semestered Labs**	**Residential DE Labs**	**Home Lab Kits**
Location Costs ($)	56	50	21
Labour			
Instructors ($)	49	43	n/a
Lab preparation ($)	3	4	47
Materials			
Equipment ($)	8†	3	24
Consumables ($)	9	9	7
Shipping ($)	n/a	n/a	33
Total Cost per Student ($)	125	109	132

*All figures are in Canadian Dollars.
† See Appendix for details.

Location costs represent the amortized, per student construction cost (or capital cost) of laboratory facilities. These were calculated using the current laboratory construction costs of a wet chemistry lab, as estimated by Athabasca University's department of Facilities & Services, of $700 CDN per square foot. This estimate compares reasonably with current published chemistry research laboratory construction estimates of $490–530 US per square foot, which does not include architectural and design fees which are typically worth 30% of the overall construction costs (Stark, Hammer & Mermelstein, 2007). It is assumed that a new laboratory space is designed for 25 years of use, at which time renovations and refurbishing would be expected.

In semestered, on-campus laboratory programs in North America, lab sessions are often three hours in duration, and three lab sections can be scheduled back-to-back, every working day. Thus, over a single week, it is easy to schedule 15 lab sections in a single laboratory room. For this arrangement, the calculation of location cost per student is done by assuming a 1200-square-foot laboratory, used by 15 lab sections per week, each with 20 students. Thus, in two 13-week semesters in a given academic year, it is possible for 600 students to use a single laboratory per course. Then, using the above laboratory construction cost estimate and depreciation, a location cost of $56 per student, per course, is found.

For AU's residential DE lab sessions that use laboratory space at other institutions, we have estimated the location cost based on our rental costs in the form of cash or in-kind payments. The location cost is competitive with semestered, on-campus programs. There are significant benefits for the laboratory host instititutions. The use of their laboratory space by a DE institution increases the usage of expensive buildings during underutilized periods, such as weekends or reading weeks when the space is not being used for their own programs. In this sense, it provides a revenue stream that is associated with virtually no additional cost. Further, at least in the Canadian system, institutional co-operation is viewed favourably by the governments that fund public institutions.

The location costs for a home lab program are much lower than for the residential DE or on-campus semestered programs. In our Chemistry 217 program, the home lab kits are prepared, restocked, and shipped from a 150-square-foot space. At any given time, most of the lab kits are in the hands of students and are not taking up any storage space in university facilities. The same assumptions of construction cost and depreciation were used to calculate location costs. We have recently been turning over home lab kits on the order of 200 kits per year. Thus, we calculate a location cost of $21 per student (i.e., per kit).

Laboratory programs have two types of ongoing labour costs. One is the cost of instructors. Lab instructors are often hired on a contingent, contract basis at a particular hourly rate of pay. Lab instructor costs for residential DE labs and on-campus, semestered labs were calculated using an hourly pay rate of $25/hour. For the on-campus, semestered labs, we assume 13 weeks of 3-hour lab sessions for every 20 students. This gives an instructor cost of $49/student. In the case of residential DE labs, we have calculated the instructor cost based on having two instructors present over 17 hours of instructional time, for 20 students. In this case, instructor costs are somewhat lower than for on-campus, semestered labs. This is mainly because of the reduction in instructional time required to complete a similar number of experiments. This can be done with no change to the experiments performed by significantly reducing the time spent by students on set-up and clean-up between experiments, and having two instructors present to increase student performance through a greater degree of one-on-one instruction. In the home lab program, instructor costs are not applicable because the student works through the entire set of experiments using comprehensive learning materials (i.e., a highly detailed lab manual).

The second ongoing labour cost is for lab preparation. On-campus lab programs often have a full-time staff member who is responsible for setting up equipment and reagents for undergraduate laboratories. For on-campus labs, we assume that approximately 3 hours is spent on preparing labs for a given week of experiments, for the 15 sections of 20 students per week who are enrolled in a given laboratory space. At $25/hour, the preparation cost is around $3 per student. For residential DE labs, the lab preparation cost is similar, with the lab coordinator spending approximately 3 hours preparing for a weekend lab session of 20 students. Using $25/hour, the lab preparation cost is $4 per student. The preparation cost for home lab kits is significantly higher because the work involves unpacking, restocking, and packing individual kits that will be sent to students. For our Chemistry 217 kits, we have tracked the length of time this requires. Our labour cost is $47 per kit.

Materials for a laboratory program include all lab equipment such as glassware and balances, and consumables such as reagents, disposable pipets, and paper towels. For a typical first-year chemistry laboratory with 20 seats, the initial cost of equipment is estimated at around $75,000 (see Appendix). Much of this equipment has a shorter life span than the laboratory itself. In this costing, we have estimated lab equipment lifetime to be 15 years. For a single laboratory used for an on-campus, semestered lab program, the equipment cost per student is $8. For residential DE labs in which some of the host laboratory equipment is used, this cost is reduced. However, when AU labs are offered in this fashion, AU equipment is often brought in. Our estimate of equipment cost per student is $3.

Consumable materials in on-campus, semestered, and residential DE labs is estimated at $9 per student. At least $2 of this goes to cleaning supplies like soap and paper towels. For a home lab program, consumable materials have been calculated at $7 per kit.

Shipping costs represent a significant portion of the total costs of running a home lab kit program. As will be discussed below, a home lab kit program can result in a larger number of students studying in geographically distant locations. This naturally means a higher average shipping cost per student.

We have not attempted to make estimates of the different costs of developing lab programs. It could be argued that development costs of a home-based lab program are higher than for a residential lab program. However, all laboratory programs have development costs, usually in the form of time spent by academic staff who research and test experiments and write laboratory manuals. In short, lab program development activities are similar between home-based and residential lab programs and we see little benefit in parsing out specific development costs.

From Table 1, it can be seen that a general chemistry home lab program has approximately the same per student cost as a similar on-campus, semestered lab program, using this set of assumptions. For DE, the most cost-efficient lab format is concentrated, residential labs. However, this is highly dependent on the number of students attending the residential DE labs. The calculation in Table 1 used 20 students. At AU, general chemistry labs are frequently attended by much fewer students. When only 10 students attend a 2-day residential lab, the cost per student can exceed $200 because of fixed labour and location costs.

The cost of home labs shown in Table 1 is based on the assumption that each kit has a lifetime of 20 uses. At this time, many of the AU Chemistry 217 kits are approaching this number of uses. There has been very little breakage of lab kit contents and it is quite possible that the kits will survive much longer than 20 uses. This would obviously decrease the unit cost of equipment to the point where the home-lab program is the most cost-efficient for institutions.

This discussion has focused on the departmental and institutional costs of running different lab programs, and has not addressed the costs to students. For DE students, the home lab program is by far the most affordable because it eliminates the need for expensive travel to attend a residential laboratory session. Even if students were required to pay the round trip shipping costs for the lab kit, it would still be more affordable than travel and accommodation costs. Our conclusion is that, in terms of costs, a home lab program is of the greatest benefit to DE providers and the students of general chemistry.

Costs of labs in the other natural sciences

The preceding costing was for introductory chemistry. The picture is somewhat different for the other natural sciences that employ practical laboratory programs — physics, biological sciences, and earth sciences such as geology. Without embarking on full cost comparisons of laboratory delivery modes in these areas, we can make general observations based on the AU experience.

In physics and geology, introductory laboratory experiments are very suitable for the home lab delivery mode, for a number of reasons. First, home kits tend to be affordable to build. For example, electronic circuit boards for electricity and magnetism experiments and diode lasers for optics experiments are all very affordable. An introductory physics kit can be prepared for under $200 (see Chapter 7).

In geology, hardness testing kits and sets of small fossil samples are also affordable. Second, kits in these areas do not generally require consumable materials, reducing the cost of home labs. Third, shipping costs of physics and geology kits are much lower than for chemistry home lab kits because of the weight of materials and because packaging is not required to be spill-proof.

In the realm of biological sciences, there is a great deal of variability. In some courses, it is not feasible to operate a home lab program. For example, microbiology experiments require large, expensive lab equipment like autoclaves and incubators that obviously cannot be shipped to the student. And in ecology, field-based teaching laboratories are appropriate. In such courses, students must attend residential supervised labs.

In other areas of biology, it is possible to operate a home lab kit. For example, one introductory biology course at AU has a home lab kit that is surprisingly affordable ($30), partly because it relies on students obtaining many consumable materials on their own. This lab kit has been described elsewhere (Holmberg & Liston, 1998). On the other hand, physiology home kits are an order of magnitude more expensive due to the costs of an electronic balance and a spirometer.

C. Home labs: accessibility and enrolment growth

Accessibility is perhaps the most important reason that students register in distance education courses and programs. For the purposes of this chapter, accessibility is a function of the student's opportunity cost to complete a course. The opportunity cost is the sum total of the costs of time, travel, and other inconveniences that students must incur during the course. As has been described repeatedly in the Laboratory section of this volume, in science courses, the laboratory component is often the most expensive in terms of opportunity cost for students.

In the Chemistry 217 course at AU, the laboratory program has undergone two significant changes in delivery format. Prior to 1996, all of the labs were delivered as two-day residential labs. From 1996 to 2002, approximately half of the experiments were delivered as home-based experiments — a "partial lab kit." These experiments have been described by Kennepohl (Kennepohl, 1996). The partial home lab kits were picked up by students when they attended residential labs to complete the other experiments. From 2003 to the present time, Chemistry 217 labs have been delivered entirely as home lab kits.

The switch in Chemistry 217 from a residential lab program to one that is based on home labs provides the opportunity to look for changes in enrolment patterns that result from the switch. Enrolment patterns in Chemistry 217 can be compared to those in the second half-course of general chemistry, Chemistry 218, which has always had a residential lab component. We assume that enrolments in a given course are a function of overall demand for the course and the student's opportunity cost to complete the course. Converting a laboratory program to home-based experiments is an obvious way to lower the opportunity cost for students by removing the requirement to travel to residential labs. Such a change should lead to an increase in enrolments in the course with home experiments, as compared to other, similar courses with residential labs.

Figure 1 shows the enrolment growth in Chemistry 217 and 218, from the fiscal years 1990/91 to 2006/07. Yearly enrolments, N, are normalized to the number of enrolments in 1990/91, N. This provides a way to compare cumulative enrolment growth as a simple factor increase in the two courses, rather than comparing raw numbers of registrations. Over the 17 years shown, the overall trend is an increase in enrolments in both courses. Until 2002/03, enrolment changes in the two courses are very similar, with Chemistry 218 showing slightly higher growth than Chemistry 217. This is likely due to an increase in the number of students returning from Chemistry 217 to complete Chemistry 218. From the introduction of the complete home lab program in 2003, growth in Chemistry 217 clearly outpaced growth in Chemistry 218.

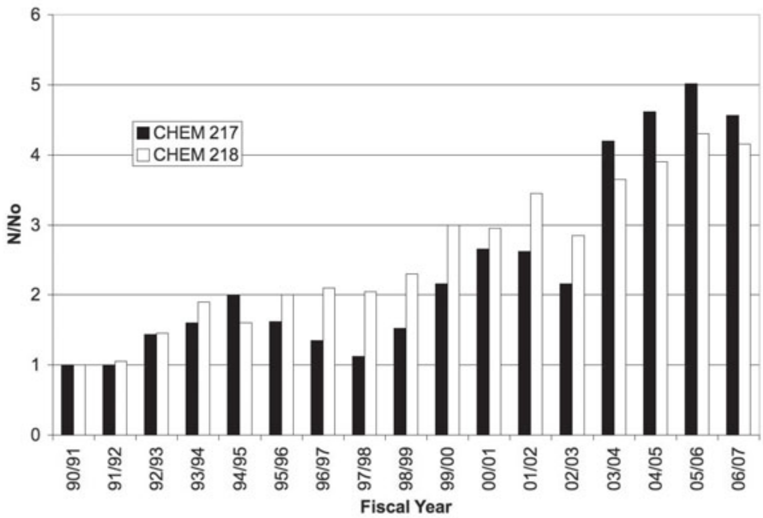

Figure 1. Normalized Enrolments in General Chemisty from 1990 to 2007. This shows cumulative growth in enrolments over this period. Enrolments excluded all early withdrawls.

The introduction of partial home lab kits does not appear to have had a significant positive effect on enrolments in Chemistry 217, from 1996 to 2002, as compared to enrolment changes in Chemistry 218. During this period, the laboratory program still used residential labs. Thus, there would have been only a minimal decrease in the students' opportunity cost to complete the labs; student travel to lab sessions was still required.

The introduction of a full home lab program in 2003 resulted in an increase in cumulative growth in Chemistry 217, relative to Chemistry 218. On examination of Figure 1, it is clear that much of this additional cumulative growth occurred between the 2002/03 and 2003/04 fiscal years, corresponding perfectly to the introduction of the full home lab program. The actual year-to-year growth in Chemistry 217 enrolment between 2002/03 and 2003/04 was a stunning 94%.

The opportunity cost of attending residential chemistry labs is expected to be highest for those students who reside outside of the province of Alberta. Thus, it is expected that the introduction of a full home lab program in Chemistry 217 would lead to an increase in the fraction of out-of-province students. Figure 2 shows the percentage of out-of-province students in Chemistry 217 and 218 from 1990 to the present. During this time, the fraction of out-of-province students has increased significantly. The out-of-province fractions in the two courses have been similar through most of this period, and have increased in step with each other until 2003/04, when the full home lab program was introduced. In that year, the percentage of out-of-province students in Chemistry 217 increased by over 20%. Since that year, the percentage of out-of-province students in Chemistry 217 has been consistently higher than in Chemistry 218. This result is consistent with the notion that home lab programs significantly decrease the opportunity cost of completing a DE chemistry course, especially for students who reside in other provinces.

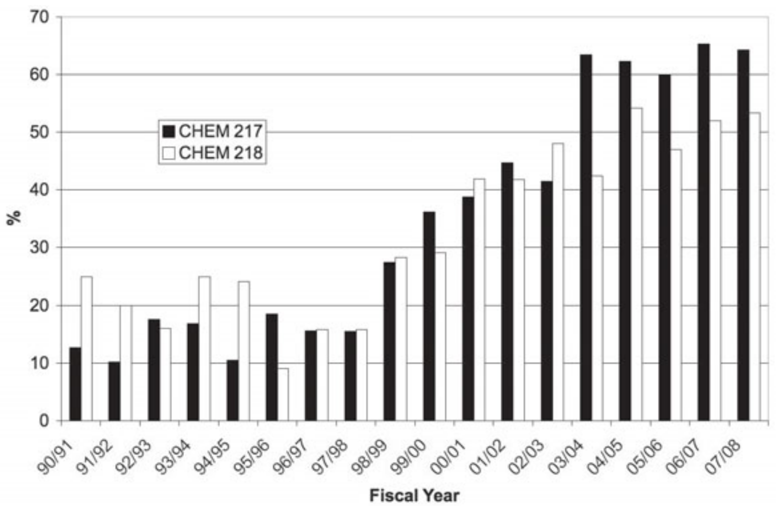

Figure 2. Percentage of Out-of-Province Students in General Chemistry from 1990 to 2007.

Conclusion

DE laboratory programs are delivered through two primary modes: the home-based lab and the residential DE lab. The organizational structure required to operate these delivery modes is different from that of traditional on-campus, semestered lab programs. Perhaps surprisingly, the full institutional costs of operating different laboratory programs in chemistry are not significantly different. Home-based laboratory programs are not associated with student travel costs, so we conclude that this delivery mode is the best choice for making DE labs accessible. This is borne out in enrolment data that shows an increase in student enrolments and an increase in geographically remote students when a full home lab program is introduced.

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APPENDIX — GENERAL CHEMISTRY LABORATORY MATERIALS AND EQUIPMENT

No.	Item	Quantity	Cost / item $*	Total $
1	Battery, 9 volt	20	1.09	21.80
2	Beaker, 50mL	100	4.04	404.00
3	Beaker, 100mL	100	2.90	290.33
4	Beaker, 150mL	100	4.04	404.00
5	Beaker, 250mL	100	2.81	280.75
6	Beaker, 400mL	100	2.81	280.75
7	Beaker, 600mL	100	4.23	423.17
8	Beaker, 1000mL	20	7.80	155.90
9	Beaker, 1000 mL plastic	20	0.55	11.00
10	Bottle, 30 mL	140	1.95	273.00
11	Bottle, 60 mL	60	2.00	120.00
12	Burette, 50mL	20	72.11	1442.20
13	Burner, Bunsen	20	26.40	528.00
14	Clamps, burette	20	20.51	410.20
15	Clamps, iron ring	20	10.21	204.20
16	Clamps, utility	40	53.28	2131.20

17	Cylinder, 10 mL grad.	30	12.14	364.20
18	Cylinder, 25 mL grad.	30	15.57	467.10
19	Cylinder, 50 mL grad.	30	2.44	73.20
20	Cylinder, 100 mL grad.	30	2.44	73.20
21	Dessicator	1	130.75	130.75
22	Flask, 50 mL Erlenmeyer	20	5.04	100.80
23	Flask, 125 mL Erlenmeyer	20	4.81	96.20
24	Flask, 250 mL Erlenmeyer	100	4.15	414.58
25	Flask, 500 mL Erlenmeyer	20	17.40	347.96
26	Flask, 250 mL Filter	20	13.86	277.13
27	Flask, 500 mL Filter	20	17.79	355.73
28	Flask, 10 mL Vol.	20	17.46	349.20
29	Flask, 25 mL Vol.	20	19.05	381.00
30	Flask, 50 mL Vol.	20	19.33	386.60
31	Flask, 100 mL Vol.	20	22.16	443.20
32	Flask, 200 mL Vol.	20	42.83	856.67
33	Flask, 250 mL Vol.	20	45.35	907.03
34	Flask, 500 mL Vol.	20	56.98	1139.60
35	Flask, 1000 mL Vol.	20	70.70	1414.00
36	Funnel, Buchner, 4.25 cm	20	43.27	865.40
37	Funnel, Buchner, 5.5 cm	20	51.42	1028.40
38	Funnel, Buchner, 7.0 cm	20	67.61	1352.20
39	Funnel, burette	20	8.18	163.60
40	Funnel, glass long stem 55 mm	20	12.68	253.65
41	Funnel, glass short stem 60 mm	20	10.94	218.70
42	Funnel, glass short stem 80 mm	20	12.20	244.03
43	Funnel, plastic	20	2.80	56.00
44	Pipette, 1 mL Vol.	20	7.33	146.60
45	Pipette, 5 mL Vol.	20	7.33	146.60
46	Pipette, 10 mL Vol.	20	7.24	144.80

47	Pipette, 25 mL Vol.	20	27.55	551.00
48	Pipette, 50 mL Vol.	20	31.73	634.60
49	Pipette, 10 mL serological	20	0.79	15.80
50	Pipette bulb(1)	20	8.01	160.20
51	Safety glasses	20	5.61	112.20
52	Spatula	20	5.62	112.40
53	Stand, retort 14×23cm	20	28.22	564.40
54	Stir bars, magnetic, teflon set	10	50.98	509.80
55	Stir rod, glass	20	0.65	13.00
56	Stopper, rubber #7	20	1.49	29.75
57	Stopper, rubber #5	20	1.49	29.75
58	Stopper, rubber 0	20	1.20	24.04
59	Stopwatch	20	23.61	472.20
60	Test tube, small	80	0.04	3.20
61	Test tube, large	40	0.05	2.00
62	Test tube rack	30	19.99	599.70
63	Thermometer, 0–110°C	20	3.75	75.00
64	Tubing, latex	60	1.10	66.00
65	Tubing, vacuum 50ft roll	60	1.92	115.20
66	Tweezer	20	1.78	35.60
67	Vial, glass — 1 dram(9)	180	0.31	55.80
68	Vial, plastic — 3 dram (3)	60	0.33	19.80
69	Vial, glass — 3 dram(10)	200	0.38	76.00
70	Vial, calorimetric	30	0.33	9.90
71	Watch glass, 65mm	30	1.37	40.98
72	Watch glass, 100mm	30	2.15	64.59
73	Wire, Nichrome (1-30 cm)	30	0.14	4.20
74	Wire, Copper stir (1-30 cm)	30	0.50	15.00

1	Centrifuge	1	4010.29	4010.29
2	Conductivity Tester	1	706.15	706.15
3	Hot plate/stirrers	20	512.92	10258.40
4	Lab Jack, 15×15 cm	20	73.02	1460.40
5	Power supply, 12 V	10	303.18	3031.80
6	Multimeter	20	20.00	400.00
7	Oven	1	1363.00	1363.00
8	pH meter (Denver Ultrabasic)	20	404.26	8085.2
9	Refridgerator	1	500	500
10	Spectrophotometer (educ 400 to 1000nm)	10	862.79	8627.90
11	Water Bath	4	968.73	3874.92
12	Analytical Balance	1	2900.00	2900.00
13	General Pan Balance 610G/0.01G	5	612.48	3062.40
			Total	**73271.21**

* Prices taken from Fisher Scientific 2007 Catalogue, retrieved September 12, 2007 from http://www.fishersci.ca/