Upgrading Computer-Based Data Acquisition Systems in Biology Teaching Laboratories

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Proposing units Ecology, Evolution and Organismal Biology
The Biology Program

Signatures

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A proposal to the Technology Advancement Committee, 2006

Project Overview and Expected Benefit

Effective inquiry-based teaching in science laboratories involves presenting students with the opportunity and encouragement to gather and synthesize data to build an understanding of emergent principles. Actual hands-on experience enhances long-term retention of principles far better than presenting a set of facts for rote memorization. Our goal is to educate students to recognize patterns, to fit those patterns into a theoretical framework, and critically evaluate that framework so they can continue to learn beyond the boundaries of the course. Laboratory experience is extremely effective in achieving that goal, because students in lab must gather, analyze, and place experimental data in the context of the information they acquire through text and lecture.

In this proposal, we seek funding to upgrade antiquated laboratory equipment used in teaching biology students. The target students are those enrolled in the Biology core courses Biol. 211 and 212 (Principles of Biology). Biology 211 and 212 are core courses within the biology curriculum; they serve majors in every science-related program on campus, with a total enrollment of 1859 students in the 2005-2006 academic year. The labs in Biol 211 and/or 212 are required in 15 of the College of Agriculture major curricula, and are required in options for three additional majors. Each of these courses incorporates inquiry-based student laboratory experiences that involve computer-based data acquisition and analysis. Each of these teaching laboratories poses a series of challenges (including learning the use of computers, software and lab equipment), encouraging students to engage in hands-on structured problem solving.

At present, our ability to engage students in this process is compromised by the current tools in the laboratories, some of which are 10-30 years old. Students perceive the lab experience as archaic because of aging software and hardware, and periodic equipment failure often frustrates student learning and faculty teaching success. This proposal is unusual in that it seeks funding to link laboratory experience with computers, rather than funding for computers themselves, which are already available from other sources. LASCAC, the departments of EEO Biology and GDC Biology, and equipment suppliers (ADInstruments) have promised more than 60% of the necessary funding. We ask for Technology Advancement funds to contribute towards the balance to provide students with modern and reliable computer-based data acquisition systems for these teaching laboratories. Such systems include software, analog-to-digital converters, amplifiers, stimulators and transducers (see Appendix I). Technology Advancement funds will be used only to purchase the front ends of those systems, i.e. the microprocessor-based units that communicate with classroom computers that run the controlling software. We need a total of 18 systems at $4200 per system to update the Biology 211/212 teaching laboratories. We currently have funding for 8, and can use one existing system.

LASCAC and the Departments of EEOB and GDCB have funded purchase of similar equipment for the Biology 335 teaching laboratory; some of that equipment can be shared between Biology
335 (Principles of Animal Physiology) and Biology 212 in the short term. The use of similar equipment is educationally important; students in the upper-division course will see the same software interface and front-end data acquisition hardware at each level of their education in biology. Although experimental design, depth and breadth of analysis differ greatly between levels, maintaining a consistent user interface and set of analysis tools will help upper division students focus on questions important to the science, rather than on achieving basic competence with a new set of tools. The same argument applies to laboratory staff and faculty: use of similar equipment will facilitate exchange of expertise between courses at different levels. Providing uniform tools for data acquisition and analysis in lower and upper division courses represents a significant innovation in the context of instruction in biology at ISU. At present, students are expected to build on knowledge and conceptual understanding of the field as they proceed through their education, but face incompatible sets of laboratory tools at each level. Our proposal will produce the same sorts of benefits that have resulted from institutional standardization on teaching tools (WebCT) and data analysis programs (JMP) at other levels.

The target student audience is described above, and includes every student on campus who enrolls in the introductory biology laboratory courses (close to 2000 students/year). Dedicated teaching laboratories are located in Bessey Hall. Laboratory data acquisition is normally confined to scheduled laboratory hours, but access to the data and analysis tools will be unlimited. The three teaching laboratories can serve up to 66 students, working in groups of 3, simultaneously. The requested software will permit round-the-clock access to stored data from any networked computer, and will permit students to use the software for data analysis on their own computers. Software will be made available to students from servers managed by the Biology Program and EEO Biology, and will be added to the public access computers in the Bessey Hall atrium. Data will be available on-line to students at any time. The classroom computers with which the data acquisition hardware will interface are normally equipped with a complete set of University site-licensed software.
Table 1 – Full itemized budget

<table>
<thead>
<tr>
<th>Description of Item</th>
<th>Number</th>
<th>Unit Cost</th>
<th>Total cost by funding source</th>
<th>Requested Technology Advancement Funding</th>
<th>Other funding</th>
<th>Other funding source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and Accessories</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 PowerLab PTB301 Teaching Systems. Biol. 211/212 Teaching laboratories. Includes software, A-D converters, amplifiers, stimulator, and transducers for laboratories in cardiac function (pulse and blood pressure, heart sounds), neuromuscular control, muscle function (force production, electromyogram), and lung function.</td>
<td>18</td>
<td>$4200</td>
<td>$42,410</td>
<td>$3,600</td>
<td>$29,590</td>
<td>Departmental</td>
</tr>
<tr>
<td>7 PowerLab PTB401 Teaching Systems. Physiology Teaching Laboratory. Includes material listed above, plus transducers and cables for isolated nerve and muscle physiology.</td>
<td>7</td>
<td>$4875</td>
<td>$0</td>
<td>$6,215</td>
<td>$27,910</td>
<td>Departmental</td>
</tr>
<tr>
<td>Software</td>
<td></td>
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</tr>
<tr>
<td>MLS210 Classroom license for Chart/Scope software. Permits student access via servers, and unrestricted installation on classroom and student-owned computers. List price $1500, included at no charge with systems above.</td>
<td>1</td>
<td>$1500</td>
<td>$0</td>
<td>$1,500</td>
<td></td>
<td>ADInstruments</td>
</tr>
<tr>
<td>Other Expenses</td>
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<tr>
<td>Shipping and handling</td>
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<td></td>
<td>$0</td>
<td>$600</td>
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<td></td>
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<tr>
<td>Total Request</td>
<td></td>
<td></td>
<td></td>
<td>$42,410</td>
<td>$69,415</td>
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</table>

Table 2 – Minimum Feasible Itemized Budget

<table>
<thead>
<tr>
<th>Description of Item</th>
<th>Number</th>
<th>Unit Cost</th>
<th>Total cost by funding source</th>
<th>Requested Technology Advancement Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and Accessories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PowerLab PTB301 Teaching Systems. (see above)</td>
<td>1</td>
<td>$4200</td>
<td>Each increment of $4200 up to the maximum of $42,410 would enable the purchase of one additional system</td>
<td></td>
</tr>
</tbody>
</table>
Partial Funding.

Currently available funding (LASCAC, departmental, ADInstruments) means that meeting a substantial part of the goals of this proposal will be feasible even without College of Agriculture Technology Advancement funding. Without Technology Advancement funding, only one of two introductory biology labs can be outfitted without sharing equipment between courses and shuttling equipment between buildings, a logistical nightmare. Any Technology Advancement contribution will be used to purchase additional teaching systems and will provide additional permanent lab stations in the introductory biology course, so that funding at any level will contribute to a successful outcome. We are still seeking additional funding from the University CAC.

Appendix I – Detailed description of proposed purchases

ADInstruments is a leader in producing data acquisition systems and biological transducers for the educational and research markets. Like their competitors, they offer teaching packages that provide significant price advantages. Those packages meet multiple teaching needs because they include each of the elements of a complete data acquisition system, including controlling software, analog-to-digital hardware, amplifiers, stimulators, power supplies for transducers, and sets of transducers that can be chosen to meet the teaching needs in undergraduate biology courses at different levels. The integrated systems simplify classroom logistics. Such a package is far simpler to manage than the collection of bits from multiple manufactures that currently characterize the biology laboratories.

Each system includes three elements, i.e., software, a hardware front-end, and a variety of plug-in transducers that convert laboratory variables to voltage or current signals that are processed and recorded by front-end hardware, the software, and the host computer.

The controlling software manages each element of the system, as well as collecting data and providing a platform for data analysis. ADInstruments Chart and Scope software are research quality tools, but have a reasonably intuitive student interface and permit establishing experiment setup files that offer the student necessary controls without overwhelming complexity. The software is used by many of our peer institutions in undergraduate laboratories at every level. A principle attraction is that with purchase of multiple systems, ADInstruments will provide a departmental site license for student use of their software (normally $1500) at no additional charge. That means we can install the software on any number of classroom computers, make it available for student use on a server, and permit students to install it on their own computers for data analysis. Versions of the software compatible with both Macintosh and PC operating systems are included. Software updates are free to licensed users.

The hardware front-ends include an analog-to-digital converter capable of sampling 4 different transducer inputs at high frequency at 16-bit accuracy, a set of integral amplifiers that permit accurate recording of tiny signals like those of human electroencephalograms, an isolated (meets IEC601-1 standard) constant-current stimulator, and full electrical isolation that meets IEC601-1
BF (body protected) and AS3200.1 human safety standards. It provides software filters that can minimize the electrical noise that is such a problem in crowded student laboratories. It includes an internal PPC 403 CPU to manage data collection and communication with the host computer. This hardware is the necessary link to classroom computers for which we request CAC funding.

The departments of EEO Biology and GDC Biology will pay for class-specific transducers that plug into the hardware front ends. The transducer package requested for the Biol. 211/212 systems will meet all the needs of current 212 lab exercises in human physiology, including recordings of blood pressure, heart rate, muscle threshold, muscle recruitment, temporal summation and tetany, lung capacity and ventilation volumes. All of these transducers are packaged with the software and front end for an additional $200; purchased separately, the cost for the minimal necessary set of transducers would be $1020.

ADInstruments will also supply at no additional charge a set of lab write-ups that describe a variety of student laboratory exercises using their equipment. Those write-ups include text and graphics, and copyright permission for unlimited duplication and distribution to students without charge. That is an advantage; some competitors (BioPac) impose a per copy charge ($1-$2) on the use of similar material. That resource that will ease the transition to new equipment, and for future innovation in our laboratory teaching. They will also send a representative to provide assistance with installation and training at no additional charge, a service they value at $2000.

We selected the A-D PowerLab system after review of multiple competitors. Products which compete in quality (BioPac) are more expensive, both for initial setup and in sustained use. Products which are cheaper (Vernier, Iworx) are less versatile (Iworx equipment is compatible only with Windows PCs); offer reduced precision, accuracy, and dependability; or do not permit key parts of exercises important in course teaching (see isolated stimulator discussion, above).