

[Project Reporting] ANNUAL REPORT FOR AWARD # 0309546

Contact Information for Project
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 Additional Information

Contact Information for Project

PI Information:

Scott D Hawke ; Willamette University
 Investigative Process & Technology in Introductory Physiology

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Participant Individuals:

CoPrincipal Investigator(s) : John G Tallman; Stasinos Stavrianeas

Type of Institution:

4YR

Partner Organizations:

Project Activities and Findings

Project Goal(s):

- 1) Establish a computerized physiology laboratory in Physiological Dynamics in Animals and Plants (PDAP)
- 2) Introduce students in PDAP to investigative, inquiry-based learning
- 3) Familiarize students with communication and data acquisition technologies

Updated Project Description:

The primary thrusts of the project are to introduce computerized data acquisition and investigative inquiry-based learning in Physiological Dynamics in Animals and Plants (PDAP). PDAP is a required sophomore-level introductory core course in biology. Additionally, there is the expectation to firmly embed the instrumentation in other physiology courses of the curriculum.

The running narrative below describes project activities and findings for two annual report years--2003-04 and 2004-05. The major accomplishments for 2003-04 were the purchase of bioinstrumentation (Biopac), establishment of K-12 outreach, and development of a student assessment plan. The significant achievements for 2004-05 centered on student use of the data acquisition instrumentation, the implementation of student assessment, and a visit to Harvey Mudd College from where the model for this project award was adapted.

In September 2003, we (Hawke, Tallman, Stavrianeas) were awarded a NSF grant (#0309546) to accomplish the objectives stated above. During the fall semester 2003, we ordered and received Biopac instrumentation to accommodate students at eight laboratory work stations. Also, we began to develop assessment tools to qualitatively and quantitatively measure the impact of the laboratory program design and new technology on learning in physiology. During the spring semester of 2004 the Biopac system was introduced to students in PDAP and Human Physiology (HP) and limited assessments were made. Our experience with Biopac foreshadows a much more comprehensive assessment of the technology on student learning to begin in fall semester 2004. It is during the fall 2004 semester that two of us will visit Harvey Mudd College to learn how well a similar instrumentation program is working in biology. A visit by an outside consultant (Dr. Mary Williams, Harvey Mudd) during the third year of the grant will provide evaluation of how well the program is operating for us. The consultant will make recommendations that can be implemented before the grant period expires in 2007.

In the fall 2004, as an element of our professional development, the Co-PIs, Drs. G. Tallman and S. Stavrianeas, visited Dr. M. Williams of Harvey Mudd College. At Harvey Mudd College the junior-level course, Comparative Physiology, is offered once a year and is not required of all majors. It is team taught with a maximum enrollment of 12 students. There are six hours per week of student contact with one

hour dedicated to 'discussion' and the remainder to laboratory work. Approximately two thirds of the lab time is committed to guided exercises. Assessments of student learning outcomes are mainly qualitative because of low student enrollments. In our implementation, the course, PDAP, is required of all sophomore biology majors, is team taught, provides three hours of laboratory time per week, and dedicates approximately 40% of the laboratory to guided exercises. Our maximum enrollment is 32 students and the course is offered twice a year. The laboratory time is complimented with four 50 minute lectures to include one laboratory recitation. Student learning outcomes in our program are quantitatively assessed. Although there are differences between Comparative Physiology at Harvey Mudd and PDAP at Willamette, the similarities to note are:

- 1) Many of the same types of experiments are carried out in both courses using similar types of equipment.
- 2) Both courses require students to develop an independent, investigative research project.
- 3) Student-faculty communication is frequent to keep projects on track.
- 4) Both institutions have modern, well-equipped laboratories to support the laboratory work.

In fall 2005, Dr. M. Williams of Harvey Mudd College will visit Willamette to assess PDAP and make recommendations to further improve the program.

A quantitative assessment of Biopac use and the ability to use the newly acquired technology to interpret physiological studies was implemented at week 12 for students enrolled in Human Physiology (HP) during spring semester 2004. The evaluation used contains five Student Learning Objectives (SLOs), some with more than one goal. The SLOs can be viewed at our Web site (<http://www.willamette.edu/cla/biology/biol244/index.htm>) as noted in the dissemination section of this report.

The overall mean response of students to the SLOs in HP was clearly below the mid point (2.50) of our four point scale ranging from 1.12 for the student has learned computerized data acquisition skills to 3.53 for the student can recognize limitations in experimental designs and methods. The less than satisfactory scoring level to all but one of the SLOs was surprising considering this evaluation was conducted during the last quarter of the course. There is no easy explanation other than it may take more than one semester of computerized data acquisition use and immersion in scientific problem solving. The students appear to be relatively naive in their ability to comprehend the scientific process using Biopac as a tool to achieve this objective.

The assessment plan for fall semester 2004 is to implement the SLOs for two other physiology courses, PDAP and Animal Physiology (AP). Additionally, there will be multiple evaluations, i.e., self evaluation at weeks 1 and 15, peer evaluation at week 15, and faculty evaluation at week 15. It is hoped these additional evaluations from several different cohorts will provide a clearer explanation of how well our Biopac instrumentation is translating in our physiology courses.

In the spring of 2004 16 students in PDAP and HP responded to a qualitative assessment of Biopac by accessing the web site (<http://www.willamette.edu/~stas/nsfevaluation.htm>). The salient conclusions were:

- the majority of students had not previously used digital data acquisition systems;
- the students all indicated they gained confidence in use of the Biopac system in their investigative class projects, although only a minority of the respondents actually did;
- the availability and ease of use of Biopac did not appear to influence their choice of investigative projects suggesting the student choices were driven by personal interests that transcend electronic recording;
- students, with one exception, acknowledged Biopac provided reliable data outputs and laboratory instructions were easy to comprehend

A concerted effort will be made next semester (fall 2004) to have the majority, if not all, students respond to the web-based evaluation. Only 16 of 43 students responded to the evaluation. A greater number of respondents reporting will give us a clearer picture of the impact of the Biopac system on our undergraduates in physiology courses.

The evaluation instrument for SLOs was implemented more fully during the 2004-05 academic year. Only those students in HP and PDAP were surveyed. Students in AP were not included in the assessment because

many of the laboratories do not utilize the Biopac equipment, but other methodology. Instead of students responding to the SLOs on our web site, we had the students respond on paper copy provided during the appropriate laboratory sessions, i.e., weeks 1 and 15. This approach elicited a response from virtually all students in HP and PDAP.

In HP all students (29 in two semesters) showed self-report progress comparing initial and end of the semester responses. Peer review showed students were more generous with their comments about their partners than themselves. Instructor comments were less complimentary, but this result is predictable based on higher levels of expectation. From these data one can conclude that students were fair in their assessments of Biopac on their learning, and that the assessment instrument reflects the same priorities and qualities in students and instructor. The results were equally pleasing from the student satisfaction survey using Biopac equipment. Based on student responses, it is evident the laboratory experience using Biopac was an integral part of their success, e.g., all students agreed or strongly agreed the utilization of Biopac instrumentation gave them a better understanding of physiology and an equal number of students indicated the Biopac system enhanced their learning of physiology. For reasons not immediately apparent, 80% of students in the first semester used Biopac for their investigative studies while only 15% did so during the second semester.

In our introductory physiology course, PDAP, student outcomes (50 students in two semesters) were comparable to the responses recorded for students in HP. As expected, self reports comparing first and final laboratories, showed improvement. Students were more capable of scientific problem solving, enhanced demonstration to critically dissect experimental designs, greater effectiveness in data analysis, and increased capability to draw reasoned conclusions. Although physiology is a challenge to comprehend, the students were better able to make connections between animal and plant physiology. As we say, 'a cell is a cell is a cell,' no matter where we find it. Peer evaluation of laboratory partners was somewhat mixed while faculty evaluation was definitely less generous but fair. The assessment instrument clearly revealed that the laboratory experience using computerized data acquisition enriched student understanding of physiology and helped them to 'think' more like a scientist. The student satisfaction survey using Biopac technology revealed students were overwhelmingly pleased

(80-90% agreed or strongly agreed) with the equipment. The Biopac system helped students to become familiar with how technology can be used in problem solving and helped them to overcome their fear of using instrumentation in the laboratory. However, less than half of the student groups used Biopac in their investigative studies, despite introducing an animal-based laboratory, i.e., frog heart contraction cycle. It is curious that many of the students want to do group projects that focus on metabolic responses of mice to drugs. These studies are not accommodated by Biopac, but can be done with Vernier and Qubit systems. Also, a number of student groups do plant studies that do not utilize the Biopac system.

The PI/Co-PIs involved in this project were favorably impressed with Biopac instrumentation after three semesters of its use in two lower division physiology courses--Physiological Dynamics in Animals and Plants (PDAP) and Human Physiology (HP). We were amazed how well the students adapted their limited laboratory skills to the use of Biopac.

The students were not intimidated by using the data acquisition equipment for the first time. The ease of use, i.e., a 'plug and run' approach and easily understood documentation allowed the students to begin operating the equipment independently in a short period of time.

As faculty we were immensely pleased how well the students reacted to this new laboratory experience. All experiments involved use of human subjects. Animal experiments are planned for the 2004-05 academic year. The animal studies are much more challenging to conduct. It will be of interest to observe how well our students respond to the introduction of animal preparations.

As compelling as Biopac instrumentation is to use, we were somewhat surprised so few students in PDAP wished to use the technology in their investigative studies. This was partially true in HP where the focus was strictly on the human model. Perhaps the absence of animal use in PDAP limited student enthusiasm for using Biopac. However, this proved not to be the case in 2004-05.

Surveys over two years of our undergraduate teachers using Biopac in the Saturday Explorations in Advanced Science (SEAS) and one year in Willamette Science Outreach Program (WSOP) revealed little change in regard to their interest in teaching public school children. However, they developed a greater understanding of what is involved in teaching students in K-12. Some were discouraged by the amount of work involved in effective instruction or were disappointed by disinterested students. Despite mild discouragement, they were all

intrigued by the challenge. The emphasis on investigation over calculation and immediate feedback with Biopac had a positive influence on children's interest in scientific inquiry. There are two target audiences for the dissemination of our Biopac technology into the wider community of K-12. They are Saturday Explorations in Advanced Science (SEAS) and Willamette Science Outreach Program (WSOP). Both programs utilize biology majors as trained teaching assistants (TAs) for the implementation of the Biopac data acquisition system. The undergraduate TAs design laboratory protocols and direct their use for the SEAS and WSOP students.

This past winter (January-March 2004) on separate Saturdays 75 students in SEAS were introduced to our new Biopac system as one of five different science activities. These students were identified primarily as talented and gifted in grades 5-9. The students were exposed first to a variety of experimental designs from EKG to respiratory cycling. Then the students were given the freedom to modify the experimental schemes and come up with their own hypotheses. The result of their efforts were exciting and meaningful. For the first time these young science minds began to think like scientists by making educated guesses as to findings and 'tweaking' the designs to further refine the outcomes. Of all the science activities in the SEAS agenda, the data acquisition study using Biopac electronics was overwhelmingly the most popular and highly rated. After five Saturdays with students engaged in different science activities, the students evaluated their experiences and selected which of the five science immersions they would like to return to for an extended lesson on the sixth and final Saturday of the program. The Biopac lesson was selected by 34% of the students as a first choice and 22% picked it as their second choice. Evidence is strong, therefore, that the Biopac system significantly piqued the interest of these young students. Once again, during the winter school term of 2005, SEAS students were provided the opportunity to work with Biopac equipment. As was true in the previous year, the grade school students rated highly the experience. The Biopac system engaged the students because it focused on their body physiology. It was a personal-types experience that transcended science theory.

It is of interest that the Biopac company contacted the PI after reading the annual report in 2004. The company asked us to 'try out' a hand-held A/D converter (MP40) that could be affordable in the market place of public schools. The device with attached electrodes allowed for non-invasive measurement of electrical signals, i.e., EKG, EEG, and EMG. This was clearly a 'plug and run' type of operation that would cost approximately \$300-400 per unit. My student assistants used the device and found that the hardware configuration (except for flimsy electrode clips), documentation, software usability, and basic functionality were superb. The downward trickle of this type of technology into the public school sector is to be applauded.

In July 2004 an audience of WSOP students (20) in grades ranging from middle through high school were invited to use the Biopac instrumentation. This group of students was primarily of minority ethnicity who indicated a strong preference for learning from the arts to the sciences. Again, with a group of young students more diverse than those of SEAS, the use of the Biopac system was an outstanding success. More than half the students considered the science exposure as their most exciting and meaningful experience. I suspect the 'hands on' approach of recording signals from their own bodies is what captured their enthusiasm for electronic recording with Biopac. Unfortunately, another annual session using Biopac is not scheduled for WSOP students in July 2005.

Other Features of Project:

There is off-campus faculty interest in our PDAP program. One inquiry from Dr. Bruce Serlin at DePauw University asked about our experiences in the animal-plant course, e.g., types of organisms used, class size, science background of students, and extent of investigative laboratories. Dr. Jacqueline Brittingham at Simpson College posed general questions about how well the Biopac technology worked, the process to hire an outside consultant to develop an assessment instrument, the incorporation of an outside consultant to evaluate the project, and the impact of the outreach component involving K-12. At the very least we were flattered by the faculty inquiries and at best pleased to see what we are doing does ignite interest outside our institution.

Activities and findings:

Research and Education Activities:

The primary thrusts of the project are to introduce computerized data acquisition and investigative inquiry-based learning in Physiological Dynamics in Animals and Plants (PDAP). PDAP is a required

sophomore-level introductory core course in biology. Additionally, there is the expectation to firmly embed the instrumentation in other physiology courses of the curriculum.

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Findings:

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Outreach Activities:

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Curricular target(s) of Project

Discipline(s) Affected by Project:

1) Biology

The Biopac system purchased with NSF funding has been used successfully for three semesters in the laboratory of PDAP. The PDAP laboratory is designed to give sophomore-level students their first exposure to the investigative process and data acquisition technology.

The technology is also used in our department's junior-level research methods course, Animal Physiology, and several majors have employed the equipment in senior research projects.

2) Exercise Science

The Biopac system is adapted for intensive use in HP with the potential for further use in senior research projects. The equipment is incorporated on a limited basis in Motor Learning where several modules, e.g., reaction time, biofeedback, and galvanic skin conduction are implemented.

Subject(s) Affected by Project:

1) Physiology

Title(s) of Course(s) Affected by Project:

- 1) Physiological Dynamics in Animals and Plants
- 2) Human Physiology
- 3) Animal Physiology
- 4) Motor Learning

Summary Description of Pedagogical Approaches:

The laboratory for use of Biopac instrumentation occupies three hours of the seven-hour-per-week course in Physiological Dynamics in Animals and Plants (PDAP). The maximum laboratory enrollment is 16 with students occupying eight work stations. Students attend three 50-minute lectures, a 50-minute laboratory recitation, and a 3-hour experimental laboratory. The class enrollment is expected to average 20 students per semester. The laboratory is the highlight of the course

since students are given the freedom to design their own physiology experiments with instructor consent. The connection is then made between laboratory practice and classroom theory. It is premature to know if enrollments in PDAP will increase and what impact it will have

on registration for other physiology courses in the curriculum.

Project Products, Publications, Materials

Journal Publications:

Book(s) of other one-time publications(s):

Types of products (e.g. textbooks, lab manuals, articles, CD-ROMs, etc.):

None

Other Types of Products:

None

Other Specific Products:

Internet Dissemination

Internet Dissemination:

<http://www.willamette.edu/cla/biology/biol244/index.htm>

The Web site has a submenu or sidebar titled NSF-CCLI. It describes the purpose of the technology grant to establish computer-based data acquisition in the physiology laboratory. It also highlights the self, peer, and faculty evaluation of student learning. The evaluation forms represent quantitative and qualitative assessments that can be accessed and responded to by students and faculty. NSF is clearly acknowledged for its support.

Additional Information

Description of Equipment or Instrumentation:

- 1) Instrumentation
 - Biopac Ultimate System, Mac (USB) x 8 work stations
 - Sensors and electrodes to support Biopac hardware

Additional Sources of Funding:

- 1) 1:1 match Willamette University \$39,897:NSF \$43,030

Special Requirements for Annual Project Report:

Unobligated funds: less than 20 percent of current funds

Categories for which nothing is reported:

- Participants: Partner organizations
- Participants: Other Collaborators
- Products: Journal Publications
- Products: Book or other one-time publication
- Products: Other Specific Product
- Contributions Within Discipline
- Contributions to Other Disciplines
- Contributions to Education and Human Resources
- Contributions to Resources for Science and Technology
- Contributions Beyond Science and Engineering
- Special Reporting Requirements
- Animal, Human Subjects, Biohazards

Contact Information for Project: Colloborating Awards

Project Activities and Findings: Innovations or Unique Successes to Date

Internet Dissemination: FTP Server Address

Internet Dissemination: Gopher Server Address

[FastLane Home Page] [Take you to the Project System Control Screen] We welcome comments on this system]