LEARNING PHYSIOLOGY THROUGH SERVICE

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A service-learning component has been successfully incorporated into an introductory physiology course at Wheaton College. In addition to regular course work, each of the 24 students spent 12 hours shadowing and assisting staff at Sturdy Memorial Hospital, Attleboro, MA, with 4 hours in the emergency room and 8 hours in two other departments. Every student kept a log of his or her observations, reactions, and learning in the field and wrote a paper on a pathophysiological condition encountered in the hospital. To compare and contrast the real hospital experience with a fictional one, the students also studied patients from the television show ER. Each week in lab, two students showed a short videotape of one particular patient and discussed the diagnosis, symptoms, treatments, and surgical procedures involved. Questionnaire evaluations indicated that this program is effective in helping students learn more physiology and exposing them to community service. Health workers and patients also agreed that providing social support to patients while shadowing and assisting hospital staff was a valuable service.

Experiential learning is an important aspect in the training process of many professions. This is nothing new in the health-care area, because specific internships provide clinical experience in every field. However, a special program for undergraduate science majors to be exposed to a real-world hospital setting is not a common practice. More than a decade ago, Dartmouth College had a program, Health Experiential Learning Program (HELP), that provided premedical students an opportunity to do internships for 10–12 weeks in various host institutions, ranging from hospitals to doctors' offices to governmental health agencies (1). Over a five-year period, almost 200 undergraduate students enrolled in this program served as nursing aides, clinical assistants, health educators, and other nontechnical staff. However, this type of program involves personnel and financial support that may not be readily available in most institutions.

Another way to provide undergraduates this critical hands-on experience is through service learning (4, 6). This paper summarizes a two-year effort of working with a local hospital to identify needs in that hospital’s emergency room (ER) that could be met by undergraduates and to develop a system that would serve those needs as well as the pedagogical goals of an introductory physiology course. The program reported in this paper shows the value of taking undergraduates to the ER, both virtual and real. The exposure to a real ER rested on a unique arrangement with the hospital for undergraduate science majors to shadow, and to a certain extent assist, health workers in the ER and other departments. Such a small-scale, short-term service-learning component of an existing physiology course to provide fieldwork experience would be ideal for small classes, particularly in a liberal arts undergraduate environment. Students can assist health-care workers in tasks identified by the...
hospital, serve as liaisons between the patients and the health workers, or just keep patients company.

Waiting is often a part of a visit to any ER and other hospital departments. If not in crisis, patients often wait for one-half to one hour before they are brought to the examination room, and then the patient may have to wait again. We have found that to have Wheaton’s biology students on duty to keep patients company, talk with them, and communicate their needs and discomforts to a doctor, nurse, or technician is extremely helpful to the patient as he or she waits for service.

At the same time, by observing the various procedures and especially by listening to the health workers’ explanations, students can learn what they may not find in the textbooks or lecture notes, or even in the laboratory. Thus the experience should fulfill the two goals for service learning: 1) to enhance learning by linking theory and practice, and 2) to help develop greater social awareness and civic skills by serving the community (4, 6). A service-learning experience also provides active and inquiry-based learning, which have been the focus of pedagogical reforms in higher education and have both proved to be highly effective in many different disciplines, including the study of physiology (3, 5). Such approaches to complement regular course work would also be involved when a student is participating in a real-world case study. Emergency medicine involves a great deal of knowledge in physiology, especially various phenomena in the cardiovascular and the respiratory systems. Participation in volunteer work in the emergency and/or other departments in a hospital should stimulate the students to learn more physiology and help them understand certain physiological concepts. Furthermore, the experience might trigger, clarify, or strengthen their career goals in the health sciences. In addition, it should foster students’ social responsibility and strengthen their commitment to service.

To compare and contrast the real hospital experience with a fictional one, the students watched excerpts from ER, the popular television show, which is known to contain some detailed biomedical information. In previous years, studying these “virtual” patient cases had already proved to help promote student interest in learning more physiology in both the introductory and advanced physiology courses. By combining these two parts of the program, I wished to obtain more than an additive effect in strengthening their motivation to gain more knowledge of physiology by 1) encouraging them to make connections between classroom and television and hospital settings and 2) stimulating them to generate questions for inquiry-based studies on real-life or television experiences.

The overall aim of the program is to provide a well-structured service-learning component in the physiology course so that 20–24 students each year will have a chance to shadow health workers in a hospital and, at the same time, to learn more physiology. The ultimate goal is to firmly establish at Wheaton College the first course in math and science with a service-learning component and to report the two-year experience so that similar programs may be tried in other institutions.

METHODS

Phase 1: Preparation

Dr. Octavio Diaz, Associate Chief of the Emergency Care Center at Sturdy Memorial Hospital, Attleboro, MA, in 1996, and Dr. Brian Kelly, his replacement in 1997, were both extremely supportive of the program. In addition, the Director of the Volunteer Department, Ann Messier, and her staff played a pivotal role in helping to get this program off the ground by approaching the participating departments and developing a schedule and sign up sheet for the class. The second year, she also prepared a special “Sturdy Memorial Hospital Volunteer Services Policy,” which describes the roles and responsibilities of all key groups involved in this program. The teaching assistant for the physiology course coordinated the scheduling, solved transportation and other minor problems, and communicated with the Office of Volunteer Services to keep records of student attendance.

Phase II: Service Learning

Each student in the class of 24 spent ~12 hours doing volunteer work at Sturdy Memorial Hospital. One-
third of the time was spent in the Emergency Care Center and the rest of the time in other departments including Physical Therapy, Radiology, the Wound Care Center, and the Clinical Laboratory. The students shadowed the assigned heath workers and helped with communication, social support, and other hospital-identified needs.

Before students signed up to go to the hospital, they attended a "Hospital in-service" session during the first lab session, on the Wheaton campus, to learn hospital regulations, health requirements, biohazards, and confidentiality issues, as well as other do's and don’ts from the Director of Volunteer Services. Each student also completed an application form.

Every student kept a log ("Sturdy log") of his or her observations, reactions, and learning in the field for the three 4-hour shifts at Sturdy Memorial Hospital. At the end of the 10- to 11-week period, each student selected his or her most interesting case from all the patients they had encountered at Sturdy and wrote a detailed paper after investigating the pathophysiological condition using reliable web sites and resources in the library. In addition, a discussion session on these papers was held during the last lab period for the entire class to share their findings and experiences.

The part of the program at Sturdy Memorial Hospital was referred to as "Internship at Sturdy", whereas the part of the program in which the students studied ER patients on the television show was referred to as "Physiology in ER." During the first 10-15 minutes in lab each week, two students were responsible for showing a videotaped section of pertinent footage on one particular patient from the episode of that week and for discussing the diagnosis, symptoms, treatments, and/or surgical procedures involved (see example in APPENDIX 1). They had to research the particular disease and prepare for the class a one-page summary of the case, including the terminology and jargon used in each of the above categories.

Phase 111: Evaluation

Students' evaluation. To evaluate the effectiveness of the program for the students, a set of questionnaires was answered by the class at the end of the semester (see APPENDIX 2). Whereas some questions asked for general evaluation of the experience, some questions provided quantifiable and specific information in the learning of physiology. The latter data were tabulated and presented as bar graphs to demonstrate how the two parts of the program ("Physiology in ER" and "Internship at Sturdy") facilitated their learning of each specific topic in physiology compared with the control condition ("without both parts of program"). Their responses were rated on a scale from 1 to 5, with 1 = "learned a little" and 5 = "learned a lot." To determine whether there were statistically significant mean differences among the three different conditions, a repeated-measures analysis of variance was used.

Hospital’s evaluation. A second set of questionnaires was also prepared for the health-care workers to evaluate the program from their point of view. A proposed third set of questionnaires for the patients was rejected by Sturdy Memorial Hospital as a possible violation of patient confidentiality and privacy. However, some indirect information was obtained by including a question concerning the students' impression, and another concerning the health-care workers' impression, of how the patients react to the program.

Instructor’s evaluation. The instructor’s assessment of the program was based on a number of quantitative and qualitative variables. The "Sturdy log" was most useful as an overall evaluation of the students' performances in the hospital, whereas their course grades, classroom discussions, library research papers, enrollment in other biological courses, and reported and actual interests in doing more service work were all used to determine the effectiveness of the program.

RESULTS

Results Based on Evaluations by Students

The data presented in this study are from the course evaluations in the second year of this program because the questionnaire used in 1996 was not as well designed as the set used in 1997. The students were asked to estimate how much more physiology they
had learned as a result of both parts of the program. As shown in Fig. 1, after studying the ER patients from the television show, the students claimed to have gained more new knowledge and developed more interests in physiology. The experience at the hospital further increased the values of both scores. They also indicated that investigating the disease conditions of the television patients broadened their perspective and increased their appreciation of the clinical applications of the basic physiological concepts. Again, the service-learning component of the course raised both of these values.

As indicated in Fig. 1, the differences of all the mean scores in this part of the questionnaire are statistically highly significant ($P = 0.001$), and there is an additive effect produced by the two parts of the program.

Students also reported on their learning of various specific physiology topics. Questions were grouped according to the organ systems, and the results are graphically presented in Figs. 2–6. As shown in Fig. 2, the students declared that they learned a great deal of cardiovascular physiology from this program. More specifically, they claimed to have learned more about blood gas transport and gas diffusion, hemodynamics and its disturbances, and blood typing and transfusion from studying the patient cases on television ("Physiology in ER"); they expanded their knowledge of each topic after their contact with patients in the real world ("Internship at Sturdy"). Although they did not gain much more knowledge of the anatomy of the heart and blood vessels after both parts of the program, they appeared to have learned a lot about EKG and arrhythmia after both endeavors. Some of the fluctuations of their responses were caused by the different departments in which they did their service learning and the different patients they encountered in the emergency or other departments. For instance, those students who spent one of their three 4-hour shifts in the clinical labs would have learned more about blood typing and transfusion than those who did not spend time in the clinical labs. As far as respiratory physiology is concerned (see Fig. 3), students indicated that both parts of the program helped them to learn a little
FIG. 2.
Effects of each part of program on students’ self-reported learning about cardiovascular physiology. Student responses (n = 20) were rated on same scale as in Fig. 1. Results are means ± SD. Repeated-measures ANOVA was used to determine statistical differences among the 3 different conditions. EKG, electrocardiogram. *P < 0.001; ‡P ≤ 0.05.

FIG. 3.
Effects of each part of program on students’ self-reported learning about respiratory physiology. Student responses (n = 20) were rated on same scale as in Fig. 1. Results are means ± SD. Repeated-measures ANOVA was used to determine statistical differences among the 3 different conditions. *P ≤ 0.001; §P ≤ 0.01.
more about the mechanics of breathing, and even more about airway structure and function. As expected, the contact with ER patients, both real and virtual, provided an excellent opportunity for the class to learn much more about the control of breathing and artificial respiration. Figure 4 combines, under the heading of neuromuscular physiology, three somewhat related topics: 1) autonomic nerves and drugs, 2) brain chemistry and therapeutic/narcotic drugs, and 3) bones, joints, and muscles. The students’ self-reported learning showed an increase after both “Physiology in ER” and “Internship at Sturdy” in all three areas. Surprisingly, the class did not report learning much more about reproductive and endocrine functions and malfunctions from both parts of the program (Fig. 4). One possible explanation may be the low probability of encountering such patients in the Emergency Care Center, Radiology, and Physical Therapy departments. On the other hand, Fig. 5 showed clearly that their knowledge of renal physiology and pathology, especially the area of electrolyte balance, benefited from both parts of the program. A unique experience for many students in the class was their chance to see patients in the Wound Care Center of the hospital. They did not learn this topic in class, but they definitely obtained first-hand knowledge of wound healing from this program. As graphically depicted in Fig. 6, the students learned certain aspects of this topic first from studying the ER patients from the television show and learned additional information after doing service learning in the Emergency Care Center and the Wound Care Center at Sturdy.

In addition to learning more physiology, the students also gained more knowledge about various health careers after both parts of the program, and consequently the interests to pursue clinical professions were triggered in many students and reinforced in others. On the other hand, the students also developed greater appreciations of all health-care workers instead of just the physicians.

As far as service learning as a component of a science course is concerned, the students overwhelmingly showed that they greatly value service learning (mean score: 4.5 ± 0.61, n = 20), and the experience significantly stimulated their interests in doing more
volunteer service (mean score: 4.30 ± 1.08, n = 20).

Results Based on Evaluations by Hospital Staff

The health-care workers, as well as the students, almost unanimously felt that the patients reacted very positively to this service-learning program. Almost all of them regarded keeping patients company definitely as "service." Furthermore, practically all the health-care workers evaluated the program as highly valuable and would like to continue their involvement with the program. In fact, two additional departments, Phar-

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Volunteer service (mean score: 4.30 ± 1.08, n = 20).

FIG. 5.
Effects of each part of program on students' self-reported learning about renal and reproductive physiology. Student responses (n = 20) were rated on same scale as in Fig. 1. Results are means ± SD. Repeated-measures ANOVA was used to determine statistical differences among the 3 different conditions. *P ≤ 0.001; ‡P ≤ 0.05.

FIG. 6.
Effects of each part of program on students' self-reported learning about wound healing. Student responses (n = 20) were rated on same scale as in Fig. 1. Results are means ± SD. Repeated-measures ANOVA was used to determine statistical differences among the 3 different conditions. *P ≤ 0.001.
macy and Cardiac Rehabilitation, participated in the program in 1998.

**Results Based on Evaluations by Instructor**

Toward the end of the semester in both years, the students handed in their “Sturdy logs.” After each one had been read, it became apparent that these logs did serve to help students connect what they read and learned in class with what they observed in the field. Most health-care workers participating in the program also spent time explaining different procedures to the students in detail. Writing the “Sturdy logs” also triggered students to research information in the library or on the web and raise questions/topics to discuss in class. In addition, these logs helped them reflect on events in their fieldwork that enhanced their civic skills and stimulated their interests to do more service work.

The contents of the “Sturdy logs” were often intriguing. In addition to detailed descriptions of the various patient cases they encountered, many students also made very insightful observations. For instance, one student in the 1996 class was impressed, as well as surprised, to learn that a lot of the diagnosis performed by the physician was by “touch.” Another student observed that teamwork was essential in the Emergency Care Center, where every health-care worker played an integral part in providing immediate help to the truly emergency patients. Most satisfying was the fact they all rose to the occasion and all handled themselves quite professionally despite the fact that a majority of them were beginning physiology students.

Although course grades of the students depended on many variables and consequently were not a reliable indicator of the effectiveness of the program, the students in both years did indicate in the questionnaires that this program stimulated them to take more biology courses, especially in the area of physiology. Furthermore, the program made them develop a deeper appreciation of community service. After the termination of the program, two students each year continued volunteer work at Sturdy once a week for a whole semester.

As far as the library research paper was concerned, many worked on cardiovascular-pulmonary problems such as myocardial infarction, hypertension, asthma, emphysema, etc. Others wrote their papers on anemia, diabetes, hepatitis, encephalitis, and other pathological conditions they came across while as Wheaton interns at Sturdy. A few students were permitted to research certain illnesses they themselves or their family members had, provided that they kept their focus on disturbances of physiological activities of certain organ systems. Because each student gave a short summary of his or her paper in a discussion session at the end of the semester, students were able to learn from each other as well as obtain more in-depth information concerning some common pathophysiological conditions.

**DISCUSSION**

This program worked much better than expected. On the basis of the different criteria, I am convinced that the students did benefit from both parts of the program. As anticipated, the enhancement in learning more physiology produced by “Physiology in ER” and “Internship at Sturdy” is indeed additive. Somewhat similar to typical case studies (2), the real and virtual patients encountered in this program provided the students an opportunity to follow the process of diagnosis and treatment as a health worker used his or her critical thinking skills to apply a vast amount of basic and clinical knowledge.

On the basis of the almost unanimous answers to one of the questions, keeping patients company was considered definitely a “service” by both the students and the health workers. Indirectly, the uniformly positive reaction of the patients to the student interns further confirmed the fact that they definitely provided a valuable service to the community.

The “Physiology in ER” part of the program was easily incorporated into the course. It usually took only the first 10 minutes in lab and did not reduce the class time or interfere with the time needed to perform the experiments each week. On the other hand, it literally made the course a little more entertaining without sacrificing any course content. In fact, I first tried this part of the program three years ago in my advanced physiology course, which concentrated on the cardio-
vascular and respiratory systems. The class responded with such enthusiasm that I decided to try it in the introductory course. We have now accumulated over 40 ER patient cases and are in the process of putting them on the worldwide web, where they will be available for physiology students in other institutions to use as alternative “case studies.” It will be entitled “ER patients.”

The main part of the program, “Internship at Sturdy,” involved a lot more work both before and during the program. It might not work for a large class, but it should be ideal for a small class in either a large or small institution. If the introductory physiology class is too large, this program may be ideal for a more advanced course, especially a course with an emphasis on cardiovascular and respiratory physiology. The location of Sturdy Memorial Hospital, only five miles away from the College, and the small size of both institutions were also factors contributing to the ease of preparation for the program as well as to the success of the program. Perhaps the hospital involved in such a service-learning component of a course should not be a teaching hospital, in which case the different departments would be preoccupied with providing regular internship programs for various allied health students.

On the basis of my own impression of the response of the class and the self-reported learning of various topics in physiology, this service-learning component of my introductory physiology course definitely helped the students learn more physiology and develop greater interests on many related topics. The program also broadened their view of how the knowledge obtained from a basic science course is applied in a real-world clinical setting. In addition, they developed a greater appreciation of all kinds of health professions and the importance of community service. Although the data presented in this paper are all from the second trial of the program, the general reaction gathered in 1996 from all parties involved, the college, the hospital, and especially the students were in accordance with the results collected in 1997. As a matter of fact, precisely because the results were so encouraging, I decided to try it again the second time around. I have now done it for the third time, and it will become a permanent feature of my introductory physiology course at Wheaton.

APPENDIX 1: REPRESENTATIVE CASE STUDY OF AN ER PATIENT

Case No. 9 (from ER, “Fear of Flying”)

By Ava Dufort and Larry Mulcahy

Scenario. After being in a traffic accident, a middle-aged man was treated at the accident scene and then airlifted to the hospital. He was admitted suffering head trauma with the possibility of intracranial bleeding. Upon arrival, the patient’s blood pressure was 70 palp, his pulse ox was at 85, his heart sounds were distant, and he was suffering from some loss of memory. A pericardiocentesis was ordered, and he was diagnosed with possible tamponade.

Symptoms
- Head trauma—severe physical injury to the head;
- Hemopneumothorax—blood and air in the pleura, lining of the lung, often referred to as a collapsed lung;
- Intercranial hemorrhaging—escape of blood in the cranium due to the loss of integrity of vascular channels; frequently, forming a hematoma; and
- Tamponade—reduced venous return to the heart due to compression of major veins by increased volume of fluid in the pericardium.

Diagnostic tests
- BP 70 palp—a systolic blood pressure of 70 mmHg as measured by the palpatory method;
- Pulse ox 85—a simple procedure using a pulse oximeter to estimate oxygen content in the blood right through the skin; normal is 95 (based on a percentage from 1 to 100);
- Pericardiocentesis—tapping a passage into a cavity with a hollow instrument for the purpose of removing fluid; in this case, paracentesis of the pericardium;
- EKG—electrocardiogram; graphic monitoring of the cardiac electric potential caused by stimulation of the heart muscle that is detected at the body’s surface;
- MRI—magnetic resonance imaging; used to make detailed images of the brain or other parts of the body to detect abnormalities or damage; and
- CAT scan—computerized axial tomography scan; used to check for brain damage.

Treatments
- Two units of blood—two pints of blood; and
Central line—insertion of a catheter into the large vein above the heart, through which drugs and blood products can be given and blood samples withdrawn painlessly.

APPENDIX 2: PARTS OF QUESTIONNAIRES USED TO EVALUATE PROGRAM

Introductory Physiology (Bio 244) 1997

Program parts were “Internship at Sturdy,” a service learning component, and “Physiology in ER,” a study of patient cases from ER, the television show.

To determine how well these two parts of the program worked, please answer the following questionnaire carefully so that changes and adjustments may be made in the future. Your response to each question should be based on an one to five scale with “1” being “a little” and “5” being “a lot”.

1) How much more did each part of the program help you gain new knowledge?
   Without both parts of program 1 2 3 4 5
   With “Physiology in ER” 1 2 3 4 5
   With “Intership At Sturdy” 1 2 3 4 5

(The three subheadings and the Likert scale were used in all subsequent questions except nos. 10, 11, and 12.)

2) How much more did each part of the program stimulate your interest in earning more about certain physiological concepts?

3) How much more did each part of the program give you a broader perspective of the dynamic interactions among the different organ systems in the body.

4) How much more did each part of the program make you recognize the application of various physiological principles in pathological conditions?

5) How much more do you understand the following physiological and pathophysiological concepts as a result of both part of the program?
   a) Electrocardiogram and cardiac arrhythmia
   b) Blood gas transport and diffusion
   c) Hemodynamics and disturbance in hemodynamics
   d) Blood typing and transfusion
   e) Anatomy of the heart and blood vessels
   f) Electrolyte balance and imbalance
   g) Autonomic nervous system, adrenergic and cholinergic drugs
   h) Airway structure and function
   i) Mechanics of breathing
   j) Control of breathing and artificial respiration
   k) Glomerular filtration and kidney failure
   l) Gastrointestinal activity and malfunction
   m) Brain chemistry, therapeutic drugs, and narcotic drugs
   n) Wound and wound healing
   o) Bones, joints, muscles, and movements
   p) Endocrine functions and hormonal imbalance
   q) Reproductive physiology and sexually transmitted diseases

6) How much did each part of the program contribute to your knowledge about careers in the health sciences?

7) How much more did each part of the program stimulate your interest to do service work in a hospital or a clinic?

8) How much more did each part of the program trigger your interest about pursuing a health career? What excited you so much?

9) How much more did each part of the program reinforce your career goal in the health sciences?

10) How much more appreciation for health workers other than physicians did you have after your Sturdy experience?

11) How well did the patients react to you?

12a) Did either part of the program stimulate your interests to take other biology courses?
   Yes___ No___

12b) If yes, which ones?

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