INNOVATIONS AND IDEAS

A METHOD OF IMPROVING STUDENT LEARNING IN PHYSIOLOGY: THE SMALL GROUP WORKSHOP

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This teaching innovation replaces standard physiology laboratories with small group workshop tasks dealing with selected physiology problems and data. Working with a series of question sheets, the students focus on establishing a knowledge base and solving problems relating to physiology. Initial experiences show an improvement in student motivation and attitude and improved feedback to students. The major benefits of this approach include 1) enhancement of written and oral communication skills, 2) listening and interacting with group members, 3) correct use of reference materials to find answers, and 4) self-reliance and improved interest in related subject material.

There is considerable oral and written comment, both in general higher education and in the sciences (1), on defining and assessing program outcomes. This interest has taken new meaning in pharmaceutical education, where curricular reform, new methods of teaching, and performance-based outcome are being advocated (2, 3). When these new standards were used, our past students in anatomy-physiology were not benefiting from the standard physiology laboratory instruction. Indeed, several questions arose concerning the value of many of the typical laboratory setups. Criticism could range from cost, failure to show expected results, the need for personnel to run such labs, and the use of live animals.

Such is the case here at The Albany College of Pharmacy (A.C.P.). Costs of equipment, animals, and personnel have outstripped our ability to continue typical physiology labs. The average class size at A.C.P. is around 125. Our program in pharmacy takes five years to earn a B.S. in pharmacy. Cost cutting by utilizing teaching assistants or graduate students is not possible, as we have no such students. Additionally, as our programs in research have expanded, there has been a reduction in teaching-lab facilities, which has necessitated doubling assigned students to each remaining teaching lab.

The cost of purchasing and maintaining physiology equipment is certainly a major argument for alternative approaches. Although some manufacturers of physiology equipment offer simpler and less costly products, these often do not meet certain requirements in the lab and usually are of only single function. Some colleges, including medical schools, have reduced expenses by resorting to demonstrations. Because the students are permitted only to observe, the learning process is hindered. Also available, in a limited selection, are video tapes that can be used to illustrate a physiological process. However, again, the student only observes.

It must be stated here that the pharmacy student’s educational goals are not primarily focused on “hands on” activity of manipulating scientific machinery or handling living organisms. Because of this, our students may not require such experiences. Therefore, we may also question the value of such standard labs when the complex procedures and equipment may distract the students from essential objectives of the topic. Our workshop approach addresses several of these questions and problems.
OBJECTIVES

The authors feel that quality time spent in organized learning effort should encourage student involvement and improve their comprehension and recall of the topic material. The objectives of our workshop innovation include:

1) Providing an alternative way to teach material that enforces learning by the student. In our approach, the student has specific tasks, rather than being placed in a general laboratory experiment possibly to miss important data and their interpretation.

2) Establishing another approach for improving the knowledge base in anatomy and physiology. The workshops guide the student to the important points, which may not have been seen in a standard laboratory experiment.

3) Providing opportunities for the student to solve problems as he/she relates to various physiological systems. Workshops allow further data or principles to be examined that may not be possible from a standard experiment in the laboratory.

4) Improving student attitude and interest toward anatomy-physiology and related subject matter. Workshops allow students to become actively involved without the frustration of manipulating scientific apparatus or dealing with living specimens firsthand.

5) Improving written and oral communication skills of the student. By the nature of workshops, the student must involve him/herself in the group, sharing and distilling ideas and information.

6) Increasing listening and interacting opportunities with group members. Workshops allow debate and cooperation in determining final answers.

7) Providing experiences for using reference materials to find answers to problems and questions. Workshops require the student to read various authors’ expressions of physiological principles and put these into their own words.

8) Improving the self-reliance of the student. Workshops provide each student with the opportunity to select his/her own personal approach for finding the answer to workshop questions. Compared with the standard physiology lab, which is often “cookbook” and lacking in thought, workshops permit each student his/her own thinking as to how to begin solving the problem or finding the answer.

METHODS

Our workshop approach is to present many of the systems of the body in such a way that students interact within a small group as they examine physiological data, graphs, tables, and reference materials. Our goal in the workshops is to provide some concentrated time for learning physiology without the attendant problems associated with standard physiology laboratories. Pharmacy students gain little from the costly and time-consuming approach of learning to operate the instruments necessary to generate required physiological information. A more effective approach would be to supply such basic material through handout or reference sources, thus leaving more time for the student groups to use this material for discussion, debate, and analysis.

Rather than possibly denying students “hands-on” opportunities, the goal is to allow the opportunity for students to examine critically the significance of the data, predict outcomes, interpret information given, and locate factual information relating to a variety of questions presented.

Our class schedules require that students attend the anatomy laboratory on one week, alternating with the physiology workshop on the other. Therefore it will take two weeks to complete both the related anatomy and physiology material as presented in the labs. Meanwhile, lecture material is being presented three days per week and is in concert with the laboratories most of the term.

Workshop sheets are received by the students several days before their scheduled appearance at the workshop. During this interval, many will have begun the exercise by using their text and the references on reserve in the learning center. Students are randomly assigned in the workshop, so each group consists of 5–6 students. The physiology workshops have the same time allotment as laboratories, about three hours, when the student groups work to complete the exercise with the aid of text and references.

Each group is encouraged and supported by the instructor, who serves as facilitator. Typical activities of the instructor include responding to a small
group as members require help, joining a small group to listen or direct the focus of the students' thinking and interacting, and raising pointed questions to the group or individuals in a group. Before any group leaves, it has the responsibility of information exchange among its members and sharing final answers and solutions for the various problems depicted in the exercise. In this way group effort is encouraged, with responsibility required of each group to delegate work assignments among themselves. Here they share and discuss information and insights gained in working on each question and problem. Most students appear willing to participate in this group effort, and laggards find out soon that their grades will reflect any lack of participation, because they fail to perform as well on the tests.

Workshop assessment includes regular quizzes in an open-ended format, usually short answer, to both the anatomy and physiology components. Additionally, several lecture tests are given, with specific questions relating to the workshops that the students have completed. Such lecture tests are of the multiple-choice variety. The final term grade for the student is calculated by weighing the lecture exams and final as two-thirds, and all of the anatomy-physiology workshop quizzes as one-third, of the course grade.

Most of the topics covered throughout the two semesters, along with some of the details required of the students, are given in outline form in the APPENDIX.

RESULTS

Early results of comparisons of our new workshop approach with similar topics presented to previous classes, using the traditional physiology laboratories, are encouraging. The format for testing in this part of the course has remained the same. On an interval of about two weeks, a quiz consisting of twenty questions is administered to the class. Students must then write short answers to open-ended questions, data, or problems. Figure 1 compares quiz grades of our anatomy and physiology students of 1989 with those of the students in the 1993 class. The 1989 students used the standard physiology laboratory approach, whereas the students in 1993 were using the new workshop approach. Applying the \( \chi^2 \) test of homogeneity, \( P = 0.073 \).

Student opinion was also solicited. At the end of the spring term a questionnaire was circulated to the anatomy-physiology class, asking the students to evaluate the overall course and how well the workshops met various of our educational objectives.

The five questions that focused specifically on how students felt about the workshops were:
1) Did the physiology workshops help my understanding and learning of essentials in anatomy and physiology?
2) Did the workshops help clarify lecture material?
3) Did the workshops enhance my ability in the use of scientific terms in explaining functions and interactions of the body?
4) Did the workshops improve my test and quiz grades?
5) Were the workshops a likeable experience?

Figure 2 shows that 90% of the students agreed with the statement that workshops helped in the understanding and learning of essentials in anatomy and physiology. Figure 3 shows that 87% of the students agreed with the statement that workshops helped clarify lecture material. Figure 4 shows that 85% of the students agreed with the statement that workshops enhanced the ability to use scientific data in
"I feel the new physiology workshops improved my test and quiz grades." Of a total of 105 student responses, 57 strongly agreed, 32 agreed, 11 were neutral, 4 disagreed, and 1 strongly disagreed.

"I feel the new physiology workshops created better understanding and learning of essentials of anatomy and physiology." Distribution shows that of a total no. of 105 student responses, 56 strongly agreed, 39 agreed, 7 were neutral, 2 disagreed, and 1 strongly disagreed.

"I feel the new physiology workshops were a likeable experience." Of a total of 105 student responses, 41 strongly agreed, 45 agreed, 14 were neutral, 2 disagreed, and 1 strongly disagreed.

"I feel the new physiology workshops enhanced my ability to use scientific terms in explaining functions and interactions of the body." Of a total of 105 student responses, 49 strongly agreed, 40 agreed, 14 were neutral, 1 disagreed, and 1 strongly disagreed.

"I feel the new physiology workshops helped clarify lecture material in the course." Of a total of 92 student responses, 52 strongly agreed, 28 agreed, 5 were neutral, 2 disagreed, and 1 strongly disagreed.

"I feel the new physiology workshops improved my test and quiz grades." Of a total of 105 student responses, 57 strongly agreed, 32 agreed, 11 were neutral, 4 disagreed, and 1 strongly disagreed.

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Our prediction is that this approach could be applied to any science course for health care professionals, with an improvement in the expected performance of many students. In the face of evidence that there is no longer enough time to present all of the mass of scientific material, the alternative is to encourage students to be more able and self-reliant in completing any gaps that might be present in their scheme of information. By guiding and encouraging students in their use of the workshop method, serious gaps in their information and understanding can be easily filled.

APPENDIX

I. Biological Control Systems: Homeostasis
A. Explain the general principle of steady state in the body.
   1. What is the importance of the cell in homeostasis?
   2. Explain the interchange between intercellular and interstitial fluids
   3. Outline how stress factors operate and the body's adjustment to stress.
   4. Compare the precision of control of several body systems.
B. Detail the concept of a "negative feedback" system.
   1. Give an exception to negative feedback in the normal body.
C. Explain the operation of:
   1. "Set point"
   2. Error signal
   3. Oscillation
D. Explain feedback operation in:
   1. Temperature regulation
   2. Blood pressure control

II. Cell Membranes and Enzyme Activity
A. Define cell membrane components.
   1. Explain the importance of carriers in a membrane:
      a) Define: diffusion and active transport
B. Outline the physicochemical factors in explaining how various materials cross the cell membrane.
   1. What relationship exists between cell pore size and many drug molecules?
   2. Make a statement regarding Fick’s First Law and cell membrane operation.
C. Construct curves to illustrate passive and carrier-mediated molecular movement.
D. Write an explanation of what an enzyme is, and its general effect on biochemical reactions of a cell.
   1. Using a diagram, explain what is meant by activation energy.
      a) Describe how a catalyst might change activation energy.
      b) Explain coenzyme function in the overall scheme of cell activity.
   2. Describe how a ligand can change the shape of an enzyme.
   3. Explain briefly: active site; ligand; allostery; enzyme activity.

E. Graph the effects of pH changes on a given enzyme.
F. Graph the reaction rate when substrate concentration is increasing.
   1. Discuss graph “F” in terms of “turnover number.”

III. Skeletal Muscle Function
A. Compare and contrast the various components of aerobic and anaerobic metabolism in skeletal muscle.
   1. Contrast oxidative muscle function with glycolytic muscle function.
B. Construct figures to represent the following in skeletal muscle:
   1. Tetanus
   2. Isotonic twitch
   3. Isometric twitch
C. Summarize the theory in connection between O₂ debt and muscle fatigue.
D. Using a schematic diagram of metabolic events in the muscle cell, name and locate each of the components described.
E. Explain changes seen in skeletal muscle when the following events occur:
   1. Immobilization
   2. Increased exercise

IV. Special Senses
A. Using a cross-section schematic of the spinal cord at several levels, draw the proper pathways for:
   1. Incoming information into central nervous system, showing location of cell bodies.
   2. Pathway of somatic motor neuron and respective cell body.
   3. Two branches of sensory neuron axon with connections to motor neurons on each side of the body.
B. Explain function of:
   1. Muscle spindles
   2. Intrafusal fibers
   3. Golgi tendon organs
C. Using diagrams of the eye, draw the shape of corrective lenses for the conditions of:
   1. Astigmatism
   2. Hypermetropia
   3. Myopia
D. Diagram the position of the two muscles which regulate pupil size of the eye.
   1. Identify the autonomic division controlling each.
   2. Tell the neurotransmitter in each.
E. Within the ear, describe the mechanics involved in transferring air oscillations into nerve impulses of hearing.
   1. Explain why changes in sound occur during otitis media.
V. Hematology

A. Write a statement that identifies and characterizes the normal red blood cell (RBC).
B. Given histories of various individuals and their blood values, respond to questions regarding:
   1. Normal ranges and units
   2. Sexual differences on blood values
   3. Laboratory tests that would be of value
C. Calculate the amount of O₂ carried by the RBCs if certain lab values are given.
   1. Explain the importance of containing hemoglobin pigment within the RBC membrane.
   2. List and explain the importance of any enzymes in the RBCs.
D. Detail the role of erythropoietin in RBCs.
E. Give any correlation between hematocrit value and hemoglobin content in a particular person.
   1. How are the following conditions reflected in hematocrit values:
      a) Polycythemia
      b) Microcytosis
F. Explain the several basic mechanisms that operate to reduce loss of blood from an injury.
G. Identify the two phases of platelet activity and plug formation.
H. Complete a flow chart in the development of a mature platelet.
I. Explain several aspects in the structure and function of fibrinogen.
J. Compare and contrast extrinsic and intrinsic pathways in blood clotting.
   1. List several ways in which the liver plays an indirect role in clotting.
   2. Briefly describe how Coumarin works in the clotting mechanism.
   3. Discuss plasminogen activators, both physiological activators and administered drugs.
K. Discuss and list antigens in relation to human blood types.
L. Make predictions when various blood types are administered to a patient.

VI. Cardiac Muscle Function

A. Describe the properties exhibited by cardiac muscle.
   1. Compare cardiac muscle to smooth muscle.
B. Discuss excitability of:
   1. Nodal cells of heart
   2. Purkinje cells of heart
C. Draw the curve of membrane potentials as they are found in:
   1. Atrial node
   2. Myocardial cells of heart
D. Trace and label the conducting pathway in a schematic of the normal heart.
E. Complete a drawing showing the relationship between membrane potential charges and resulting contraction of a cardiac muscle cell.
F. Explain the two phases of the cardiac cycle.
G. Calculate the average amount of blood pumped under rest and exercise conditions in the normal person:
   1. Explain the reduction of end-diastolic volume under increasing heart rate.
   2. Explain a tracing which shows ventricle response to stretching.
H. What characteristics are seen when heart muscle is under the influence of:
   1. Sympathetic nerve system
   2. Parasympathetic nerve system
I. How are neurotransmitters important in changes in pacemaker potentials?
J. Compare and contrast atrial and ventricular fibrillation as to:
   1. Mechanism
   2. Causal factor
   3. Life threat

VII. Blood Circulation

A. Explain how the body’s “pressure reservoir” operates to maintain blood flow through the tissues.
   1. What changes are found in compliance of vessels with arteriosclerosis?
   2. What three factors are related to blood flow resistance in the normal circulatory system?
B. Inspect a graph expressing blood pressure (BP) values in different parts of the systemic circulation and then respond to the following:
   1. Where does BP change the most?
   2. What feature of the large veins contributes to the pressure values found there?
   3. Why is the fluctuation in pressure seen in the aorta and large arteries?
C. Calculate the mean arterial pressure (MAP) when the BP is 130/78.
   1. Why is the resulting value not halfway between systolic and diastolic values?
   2. How will this value (MAP) change if a person develops hypertension?
D. What is meant by “pulse pressure”?
   1. Give three normal factors which determine the magnitude of the pulse pressure.
E. Give a brief explanation on how the sphygmomanometer is used to measure blood pressure.
   1. What produces the distinct sounds heard through the stethoscope when BP is taken?
   2. State the relationship between turbulence in a blood vessel and the velocity of flow.
F. Locate the vasomotor center, and explain how it controls BP.
   1. From a figure, explain the changes that occur during total spinal anesthesia, and later, when norepinephrine is injected into the patient.
   2. From a figure, explain the BP changes which result from carotid clamping, and later, when the carotid clamps are released.
G. State the ultimate function of capillaries in the scheme of the cardiovascular system.
1. Show a set of normal values which illustrate net fluid movement and effective filtration pressure.
   a) Explain how hemorrhage would alter capillary pressure and net movement of fluid.
   b) List several basic causes of edema.
   c) What is the major function of lymphatics in cardiovascular homeostasis?
H. Develop an explanation of the mechanism involved in BP control when blood flow is reduced to the kidneys.

VIII. Lungs and Breathing
A. Explain the mechanisms of breathing, with reference to different pressure values which occur during this event.
   1. Why will a lung collapse when an opening is made in the chest wall?
      a) Give the normal value of intrapleural pressure.
      b) How would this value change in a pneumothorax?
B. Using a diagram of the lung and thorax wall, complete the correct numbers in the proper locations which explain atmospheric and alveolar changes acting on the tissue during normal breathing.
   1. What is the general idea of Boyle's Law as it applies to pressure changes in our lungs?
   2. Identify that part of the respiratory tract which offers the most resistance to air movement.
   3. Tell how pulmonary surfactant operates.
      a) How is respiratory distress syndrome related to surfactant levels?
C. Graph and explain the various spirometry values of lung volumes and capacities.
   1. How do lung volumes change in the condition of emphysema?
   2. When using spirometry, explain how Forced Vital Capacity (FVC) value acts as a useful diagnostic tool.
      a) List some respiratory diseases which might be evident in abnormal forced expired volume or FVC values.
D. Describe the location of external respiration in your body, and name the major gases involved.
   1. List several important factors that affect external respiration.
      a) Which factor could easily be influenced by drugs?
   2. Using a figure, show the equilibration of blood oxygen with alveolar PO2 as a function of percent capillary length.
   3. Determine the relative gas pressures of O2 and CO2 as they occur in capillaries of body tissues.
E. Given certain data, solve the problem of whether a patient is receiving adequate alveolar ventilation when being artificially ventilated during surgery.
F. List and explain the various ways that erythrocytes are adept in the scheme of proper internal respiration.

IX. Nutrition and Calories
A. Discuss the calorie (kilocalorie) with regard to energy and heating value in foods.
   1. What experimental method is used to determine such values in foods?
B. Using any required tables, describe two methods of calculating your basal metabolic rate (BMR).
   1. List several important conditions which must be met to have "true" basal conditions.
   2. What relationship is there between body temperature and metabolic rate?
C. Discuss the function of the thyroid gland on BMR.
D. Calculate the number of calories released from one gram of protein, carbohydrate, and fat.
   1. List those foods high in carbohydrates, fat, and protein.
E. Compare your current BMR caloric requirements to the following:
   1. pregnant female
   2. lactating female
   3. 50+ year-old male or female
F. Calculate, using tables, your ideal weight.
   1. What percent over "ideal" is considered obese?
   2. Explain the two classifications of clinical obesity.
G. Explain "nitrogen balance" in the normal person.
   1. Give conditions that might bring on negative nitrogen balance.
   2. List several hormones which stimulate protein synthesis.
   3. Why are carbohydrates called "protein spacers"?
H. Using charts, tables, etc., the remaining part of this workshop instructs students to determine for the previous day the amount of calories taken in (food intake) vs. the amount of calories burned in various activities and exercises.

X. Kidney Function
A. Outline the basic renal processes in glomerular filtration.
   1. Using a diagram of the nephron, locate and identify two other general processes which alter the urine composition.
B. Discuss the blood pressure to the kidney and compare
structure-function of the kidney capillaries to those capillaries in most other body areas.

C. Using three separate diagrams of the nephron, explain and illustrate the different response of the kidney to three different compounds.

D. Examine a table showing components that undergo filtration and absorption, and draw conclusions from data in the table.

1. From a list of normal components in the body, decide what reabsorptive processes of the kidney are active and which are passive.

2. From a list of drugs, describe how each might be handled by normal kidneys.

E. Given a normal person who is on a high salt diet with minimum water intake, explain several functions of the kidneys to maintain homeostasis.

F. Explain the link of cardiovascular baroreceptors to renal sodium regulation.

1. Tell the role of renin and angiotension II in regard to aldosterone secretion.

G. Outline the response by kidney nephrons to a rise in extracellular potassium.

H. How is kidney function altered in:

1. Prolonged vomiting

2. Severe diarrhea

I. How does a diuretic act upon the human body?

XI. Reproductive and Endocrine Function

A. Identify and give examples of the two main ways in which hormones are transported in the blood.

B. Explain why some target cells respond to the effects of hormones and other cells do not.

1. Explain the concept of "second messenger" with regard to a hormone’s action.

a) How does cyclic AMP operate as a second messenger within the cell?

C. Detail the several types of hormonal interactions thought to occur, with examples of those hormones.

D. Construct a list of those hormones that are elaborated by the pituitary gland, and give examples of target organs.

E. Tell the single most important effect of the thyroid hormone.

1. Name two substances that specifically inhibit the formation and release of thyroid-stimulating hormone.

2. Explain several of the consequences of excessive thyroid hormone.

3. Give the effects of inadequate thyroid function in babies and adolescents.

F. Identify the two gonadotropic hormones that play a starring role in the ovarian cycle of the human female.

1. Using a graph, sketch the daily plasma levels of each gonadotropic hormone.

a) On the graph, indicate the following points: menstrual period, follicular phase, ovulation, and beginning point of chorionic gonadotropin of pregnancy.

2. Using a graph, sketch the daily levels of each ovarian hormone.

a) On the graph, indicate the following points: menstrual period, proliferative phase, ovulation, and secretory phase.

H. Using a table compare the effects by the two hormones from the pancreas upon:

1. Liver glycogen

2. Body fat stores

3. Blood glucose levels

I. Locate and name four hormones of the adrenal gland.

1. Detail and explain the various physiological effects of each.

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