USING ROUND TABLE LABS TO COMPLEMENT DIDACTIC LECTURES AND EXPERIMENTAL LABS

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In an effort to teach the volume of material needed by physiology students as well as to enhance the student's understanding of physiological mechanisms, a combination of teaching methods is being used at the undergraduate level. Didactic lectures are used to convey the mass of information needed, experimental labs are used to aid the student in visualizing concepts, and situational labs [called round table labs (RTLs) here] are used to provide an opportunity for the student to learn, in a risk-free setting, how to answer application questions. The RTLs utilize discussion, writing, verbal communication, and analytic thinking. The major emphasis of the RTLs is on the integrative nature of physiology. Use of the RTLs bridges the gap among the facts learned in the didactic lecture, the hands-on learning of the experimental lab, and the need to be able to apply what is being learned. Using this combination facilitates student learning such that the student reaches a level of proficiency with the subject beyond that which can be attained with the more traditional lecture-exam format.

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The number of papers regarding pedagogical methods used to improve student learning has increased in recent years, particularly for content-rich subjects like the sciences. Many science educators are moving from the more traditional lecture-exam format to alternate methods that involve the student in a more active learning situation.

A lecture format is generally the teaching method of choice in teaching physiology, particularly to a large number of students. Such courses tend to emphasize the various organ systems but omit a complete discussion of the integrative nature of physiology. The same pattern is also found in most physiology textbooks. This teaching emphasis may not be the best approach for promoting comprehension in a subject, such as physiology, for which multiple levels of information exist. Students are asked to master a range of material, from the molecular basis of skeletal muscle contraction to the influence of total blood volume on cardiac output. The lecture method serves to convey a volume of scientific knowledge, but it may not truly facilitate the student's understanding of the material or her/his ability to apply the information.

In an attempt to enhance student learning in physiology, a variety of teaching formats have been reported. Richardson (6) introduced common human situations as experiments during the lecture, and he reported that students asked better questions and interacted better with the instructor. Still another strategy for improving student learning is the use of case studies (3), a method that before 1994 was found predominantly in the study of business, law, and medicine.

Although the case study method has not gained wide acceptance in basic science education, its use in one anatomy and physiology class is reported to have sharpened the students' analytic skills and to have increased the students' understanding of facts, concepts, and principles (3). As noted by Herreid (4), the goal of case method teaching for the most part is not to teach content as much as it is to teach science process and to develop critical thinking skills.

One case method strategy, problem-based learning (PBL), is used in medical schools across the country but appears to be used in relatively few college science classes. It has been reported that, in general, students prefer PBL to the more traditional teaching format because their interest is engaged (1). However, fewer topics can be covered so there is, overall, less breadth of knowledge gained. For some students, the level of frustration rises if the problem requires too much time and labor (1), so it is not a perfect teaching strategy for every student. Sometimes instructors will choose to use an occasional case study in an attempt to cover more subject matter, but it is hard for both the teacher and the student to feel comfortable without consistent usage of cases (4).

It is interesting to note that for women and ethnic minorities, the PBL approach is believed to be a better method of science learning because it uses those teaching practices that maximize gender and ethnic equity (2, 7). These practices would include one teacher for every four or five students and a ''team'' that works through the cases together for an extended period of time (an entire semester or year) (4).

My physiology courses (Human Physiology for nursing majors and Comparative Physiology for biology/chemistry majors) typically enroll between 24 and 40 students. Although these are not large lecture sections compared with those in many universities, maximizing student learning is still a critical issue. Both physiology courses have a required laboratory component that is devoted mainly to experimental labs. The didactic lecture is the pedagogy used in the classroom. I have recently added a third teaching method, the round table lab (RTL), which provides an integrative experience for the student. The RTL has, to date, been the key to moving my students to the level where they ''think'' physiology.

OBJECTIVES

The RTL is a type of case study or problem-based method. The RTL design relies on knowledge the student has gained from both lecture and experimental lab situations and is more of a process than an exercise. Students start with their own knowledge base and a given physiological situation (essentially an application-type question that would be asked on an exam). They then work their way through the RTL question—what they know, how it affects the question, what else needs to be considered—until they can explain the underlying mechanisms in the situation. Writing and, for many students, illustrating these steps with all the interconnections is imperative for keeping thoughts organized. Through this process students begin to truly understand the complexity of physiological systems. (APPENDIX I details 6 specific features of the RTL.)

The RTL is intended to be a block of time (a 3-h lab works well) in which students can accomplish several things:

1) Gain practice in examining and explaining physiological situations. The RTL experience forces students to learn to prioritize the given facts and then organize them in a way that connects to something they have learned in lecture and/or lab.

2) Model after the instructor, who will work with the students through the process of examining a physiological situation in its application. Dependence is expected at first, with more and more independence as the semester progresses.

3) Gain confidence in looking at and working with applications of the science they are learning.

4) Self-reinforce the material by verbalizing the information to lab partners. I have found this to be a critical component in this process. By detailing the material orally, the student is forced to be concrete, specific, and clear in her/his explanation, which facilitates the student's own learning.

METHODS

Because Saint Mary's College (a liberal arts institution for women) is small, we are able to limit our lab enrollment to ~16 students. The setup in my physiology lab is to have four lab groups with four students per group. Both the experimental labs and the RTLs are used to demonstrate, emphasize, and practice the material taught by didactic lecture in the classroom portion of the course.

The RTL is currently held four times during the semester, scheduled so as to immediately precede exams. Except for the first RTL, which is held after a shortened experimental lab, the RTL replaces an experimental lab for the week it is scheduled. This arrangement works well because it is within the lab structure that there is an uninterrupted block of time to hold a ''round table discussion'' of specific physiological problems.

Correct answers are important but are not the ultimate goal of the RTL. The focus is, instead, to have the student become independent in her/his exploration and explanation of an unknown physiological situation. The RTL becomes a type of triage exercise, and the more practice the students have, the better their analytic and critical thinking skills become. This is all accomplished without assigning a grade. The RTL is strictly practice ground that is risk free, a fact that appears to help the student participate more readily.

Questions used in the RTL are structured initially as simple, straightforward inquiries. As the semester progresses, the level of difficulty increases. One RTL focuses entirely on endocrine systems and the feedback regulation associated with those systems. APPENDIX II lists sample questions and answers that have been used in the RTLs early in the semester, approximately midway through the course, and in the final weeks of the semester preceding the final comprehensive exam. Please note that the statements included in APPENDIX II are brief and do answer the question, but they would not be adequate for the purpose of the RTL. Answers required of the students are to be much more complete and should include integration with related systems.

The format of the RTL is to present the question and then take 30–40 min to identify important points, detail the situation, and relate the condition to normal physiology. During this initial look at the situation, students are to write down the important points, discuss each point in detail with their lab partners, look up any information they don't know or can't recall, talk about it again with their lab group, and then write the final commentary about the situation. The teacher circulates continuously, checking progress for each group and directing students back to the central question as they get diverted in their explorations.

After the initial discussion, other questions are investigated that require students to integrate information from their knowledge of other organ systems. These ''additional'' questions are generated as students progress through the original dialogue or are planned by the instructor, and they therefore require the teacher to be well prepared for the RTL. The overall focus in the last half of the RTL is integration. Total time for the first RTL may only be 90 min, but if students need more time, it is available. In later RTLs, more information is covered per question, and as many as three separate situations are presented so that most of the lab period is utilized.

The ''starter'' RTL questions are designed around the current topics being covered in lecture and in the experimental lab. As previously stated, it is very important for the faculty to feel comfortable with this approach to teaching science. The additional questions that inevitably arise may not be in the ''script'' of the RTL, and the teacher must be able to field such questions to make the RTL a positive learning experience. The RTL begins as a very structured exercise and moves to a more open-ended discussion as new thoughts and insights are introduced. The teacher of the RTL must keep the exercise focused while allowing students to explore various avenues related to the central idea.

RESULTS

Student performance. From a numerical perspective, the students who begin the course performing below the 70% level have the most to gain in terms of improving their grades. This is the population for which the following comparisons are being made.

Before beginning the RTLs, I had one or two students a semester who improved as much as 15 points from the first exam to the second or third exam. Without exception, these were students who came in for one-on-one tutoring sessions. I observed in these students a transition from memorization to analysis and application. They were not always very proficient at this new way of processing ideas, but it was a start.

I began using RTLs one year ago in an attempt to encourage all students to rely on their abilities to think analytically and logically rather than depending on memorization. For many students, this was a difficult transition because memorization was the learning style on which they had depended for many years. Since beginning the RTLs, I have had students improve as much as 37 points, going from an F in the course to completing the course doing B work. In my third semester of using the RTL method, I saw a very dramatic improvement in one course. Out of eight students (of 24) that got 70% or below on the first exam, six improved their grades on the second or third exam by an average of 20 points. From my observations, once the students reach a certain level, they remain at that numerical standing throughout the semester. Thus the improvement appears to be permanent.

The exceptional improvement of this past semester was due in large part, I believe, to the fact that I am more comfortable leading RTLs now. Students benefit more when the teacher is confident in leading the discussion because students need that support as they are learning and because students model after the teacher in their approach to the situations.

Subjective evaluation. For those students who perform at a higher level from the beginning of the physiology courses, the evaluation of the success of the RTL is a bit more subtle. On the basis of the confidence I observe in students in answering application-type questions on exams and in pursuing graduate study in physiology or other science areas that require them to integrate information extensively, I would say that the RTL experience has contributed positively to the development of analytic skills in those students.

Specific comments from students are:

''This is why I majored in biology—to see how all the stuff I like fits together.''

''This [RTL] helped me so much. Now the [lecture] material makes so much more sense.''

''I knew the details before, but this forced me to look at the overall picture and see how each part fits into the whole.''

''Now I don't get so freaked out at those long answer [application] questions you put on the test.''

One of the most rewarding developments I see taking place in students as the course progresses is the talk outside of class, initiated on their own, about physiological situations. The more academically adept students have always tended to engage others in ''physiology conversation'' by the end of the semester. However, this past year, and especially this last semester, students from all levels of the grading scale were talking with roommates, parents, etc. about some physiological phenomenon. And in the final RTL of last semester, one student, who hadn't done particularly well all term, was explaining all the interactions among the various hormones under discussion to her lab partners! Correctly, I might add!

DISCUSSION

McKinley and Stoll (5) and others (1, 3, 4, 6) have reported personal successes or experiences with the problem-based/case study/workshop method of teaching physiology. In all circumstances, the idea is to get students to discuss and think about physiological systems rather than just memorize facts. The RTL is another teaching strategy that emphasizes active learning. In the RTL, the student is required to participate in on-site discussions, to have a working knowledge of the underlying physiology, and to effectively communicate information to her/his lab partners.

It has been reported that using PBL causes the role of faculty to change from that of dominating student learning to supporting student learning (1). In many ways, using the RTL technique causes a shift in roles for both the teacher and the student. The teacher, who in the didactic lecture is responsible for imparting information to students, is now called on to encourage and lead students while providing information only occasionally. The student's job in the RTL is to be more responsible for and be more actively involved in her/his own learning. The fact that the RTL is an ungraded component of the physiology courses contributes to its success. The main focus for the RTL is to get the students to think, discuss, write, ask questions, develop ideas—in short, to stretch themselves intellectually. The risk-free nature of the RTL promotes all these activities.

The team approach as found in the lab setting works very well for developing and discussing RTL questions. Students work together in the same small groups all semester and so are quite comfortable with each other. Also, with only 16 students in the lab, it is easy to periodically intervene with whole class commentary as needed.

CONCLUSIONS

After working with precollege science students and teachers for 5 years and with college physiology students for more than 14 years, it is readily apparent to me that people learn best by repetition and reinforcement. In the case of a student performing well on application questions, opportunities should be provided for the student to practice the strategy required of these questions. A student must first learn HOW to approach any application problem, pinpointing where to begin and how to proceed from there, and then she/he must practice the skills within a risk-free environment where her/his mistakes are not penalized. The end result of this practice is that students begin to rely on their own abilities to figure out new situations instead of remaining dependent on a teacher for the answers.

Proficiency in physiology means understanding the mechanisms involved in organ systems and knowing how these mechanisms affect the intact organism. It is the combination of traditional teaching methods (didactic lectures and experimental labs) with more process-oriented techniques such as RTLs that creates an environment where depth and breadth of learning can take place.

APPENDIX I. SPECIFIC FEATURES OF THE ROUND TABLE LAB

The round table lab (RTL)

1) Takes advantage of small group situations such as one finds in most labs (16–18 students).

2) Is based on the premise that students can't master everything in the textbook in a single semester, but they can learn the important basic facts and then thoughtfully work their way to a number of solutions based on what they know.

3) Is based on building blocks. As more conceptual facts are learned, the situations presented become more complex and students learn to integrate many pieces into the whole.

4) Is based on the idea that practice may not make perfect but it at least develops a solid level of proficiency. That practice includes verbalizing information, which aids the learning process.

5) Teaches organization. Physiology questions will generally have a number of avenues that must be examined and explained fully. Students often get caught in the complexity of it all. This strategy teaches them to be more methodical about their approach—to start at the core problem, find a direction and follow it to the end, and then come back to the core and follow a new direction. The avenues will eventually intersect, which also teaches the student the integrated nature of the subject. Writing this information is critical for the student to keep her/his direction of thought.

6) Teaches a way of thinking, particularly when used with other methods that convey large volumes of material (didactic lectures) and that aid in the visualization of concepts (experimental labs).

APPENDIX II. SAMPLE OF SITUATIONAL PROBLEMS USED IN EARLY, MIDWAY, AND FINAL RTLS

Early RTL

What causes rigor mortis? [The student must understand the physiology of muscle contraction to answer this question.] The key points are knowing that the muscle needs ATP to *a*) replace ADP on the myosin head so it detaches from the actin binding site and *b*) pump calcium ions back into the sarcoplasmic reticulum. Cellular death means no ATP production, thus the steps using ATP will not occur.

How do you know that dendrite membranes of postganglionic parasympathetic neurons contain cholinergic receptors? [The student must know the autonomic nervous system for this question.] Because the neurotransmitter between the preganglionic neuron and the postganglionic neuron is acetylcholine.

Why are splanchnic nerves considered part of the sympathetic nervous system? [The student must know the differences between the sympathetic and parasympathetic divisions of the autonomic nervous system.] Because the splanchnic nerves arise from the thoracolumbar region of the spinal cord, they travel to the sympathetic chain of ganglia even though they do not synapse there, and they release acetylcholine onto a postganglionic neuron at a collateral ganglion. The postganglionic neuron then releases norepinephrine (or epinephrine in some animals) onto the effector cell.

Midway RTL

When a frog is pithed by probe, the legs "stiffen" during the destroying of the spinal cord. Why? [Students must know nerve function, muscle function, and the connection between neurons and muscle fibers.] The probe causes action potentials to travel down the motor neurons to all muscles in the legs so they all contract at once. This causes the legs to fully extend during the pithing procedure.

Detail the female cycle after puberty and before menopause. Distinguish where all hormones originate, where they act, what they do, and the phase of the cycle in which they are prevalent. What happens to the cycle if an ovariectomy is performed? [Knowing the normal female cycle is essential.] An ovariectomy removes the source of the sex steroid hormones estrogen and progesterone. Thus the actions caused by these hormones will not occur. In addition, no ovum can be produced because the ovary has been removed.

A pregnant woman has a heart rate of 160 when she lies on her back. When she turns on her side, however, her pulse drops to 72. Her doctor tells her she has vena caval syndrome but nothing more. Explain to her in detail why her heart rate varies so much. [An understanding of cardiac output and those parameters that influence it are necessary.] When the woman is lying on her back, the fetus is pressing on the woman's vena cava and decreasing venous return. A decreased venous return means a decrease in stroke volume. To maintain a normal cardiac output, the heart rate will increase to compensate for the low stroke volume.

Tetrodotoxin from the Japanese puffer fish, DDT, and local anesthetics xylocaine and procaine all cause numbness to some degree. Detail how they work. [The student must understand nerve action potentials and the sensory system.] These chemicals act by varying means but will in general block ion channels from opening or closing. (Students should know the details of each one.)

Explain the antagonistic and/or agonistic actions of atropine, curare, propranolol, phentolamine, phenoxybenzamine, phenylephrine, and epinephrine. [Students must understand what an antagonist and an agonist do. They must also understand where the various types of receptors are located and what their normal function is.] The first five chemicals listed here are antagonists to either cholinergic or adrenergic receptors. They are specific for certain receptor subtypes and block the normal response. The last two chemicals in the list are agonists and will stimulate the receptor to which they specifically bind. (Students should know the details of each one.)

Final RTL

For these situations, the students must decide what each of the points are that need to be addressed. They then must follow each of those points to completion, one by one, until they have an integrated picture of the whole.

A young woman is injured in a fall from a ladder. She hits her face on the ladder and breaks her nose. When she hits the ground, she is bleeding profusely and a cracked rib causes her right lung to collapse. Discuss the various physiological mechanisms that will already have been activated in this woman's body by the time help arrives. Students must discuss the consequence of a broken nose, profuse bleeding, and a pneumothorax. They must also talk about what branch of the nervous system would be activated in the woman during the fall, including the signs of that activation. Overall, they must describe the mechanisms at work to maintain homeostasis.

An individual has just been brought into the hospital with massive hemorrhaging. What events have occurred in the body already to maintain life? A complete discussion would involve blood clotting, hemostasis, maintaining blood volume, maintaining blood pressure, a change in urine production, and adjustments in hormone levels in the bloodstream.

An individual is on safari and gets lost in the desert. She is found after three days in a very weakened state. She is extremely thirsty, has a high but weak pulse, is breathing rapidly, and can barely stand on her own. How do the cardiovascular, renal, and respiratory systems work together to maintain homeostasis in this individual? Students must think about dehydration, a need to maintain a normal blood pressure, and the high metabolic demand on the tissues after 3 days in the desert.

A person is taken to the hospital in a coma. The lab results show a blood sugar level of 600 mg/dl. You notice a fruity breath smell and rapid breathing, and the family tells you the patient has been urinating frequently for several weeks. A urinalysis reveals a urine pH of 4 and the presence of ketones. Explain renal, respiratory, and hormonal mechanisms at work. To explore this situation, the student must understand both normal and abnormal blood sugar regulation, changing nutrient/fuel use when glucose is unavailable, causes of hyperventilation, changes in urine production, significance of urinalysis results, and overall adjustments ongoing in the body to maintain homeostasis.

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