The symposium entitled “Dynamic Methods for Improving Undergraduate Physiology Education” was part of the 38th International Union of Physiological Sciences (IUPS) World Congress program and occurred on August 3, 2017, in Rio de Janeiro/RJ, Brazil. The symposium was proposed by Pâmela B. Mello-Carpes, from Brazil (chair), and co-chaired by Barbekka Hurtt (USA) and was intended to discuss alternative methods for improving physiology learning in undergraduate students.

The 2-h symposium consisted of a short introduction to the theme, followed by five talks of 20 min each, and concluded with 15 min for audience questions and panel discussion. This session attracted a large number of delegates (conference hall capacity filled and standing room only). Indeed, we understand this symposium was among the most popular in the program. But what made it so popular? In our estimation, the symposium theme was relevant for the entire physiology community participating in the congress, including physiology professors and undergraduate and graduate students who will teach physiology in their future career, since an important challenge for physiology professors is to make physiological concepts interesting and significant to students, and we discussed different ways to do this.

In her introductory remarks, Pâmela Mello-Carpes explained that the use of student-centered teaching methods assists the students in building on previous learning and drives them to actively engage in their learning experience and to prepare to be knowledgeable future professional (12, 13). Furthermore, since physiology is sometimes a difficult course, physiology professors need to be conscious that different and/or alternative teaching-learning strategies are preferable for helping different students learn more effectively. The use of methods that stimulate the students to develop their own questions, draw on their own experiences, analyze and interpret data, and draw their own conclusions are always preferable to make the content more relevant, significant, and memorable to promote the long-term retention and application of knowledge (2, 5–7, 16, 19, 20, 23).

Traditionally physiology has been taught as a classroom course, with a mixture of lecture and, eventually, laboratory or workshop experiences to introduce concepts. In this symposium, we discussed alternative methods for improving physiology learning in undergraduate students. The themes proposed reflected the experience of the invited speakers. The team of speakers was composed of physiologists from different countries and universities (Australia, Brazil, and USA), which favored the exchange of experiences and ideas.

Multimodality Learning: Implementation of 3D Technologies in Anatomy and Physiology, by Barbekka Hurtt

Barbekka Hurtt’s presentation focused on the implementation of three different three-dimensional (3D) technologies (simulation, imaging, and printing) to promote student engagement, interaction, and knowledge development and application. The 3D simulation program allows students to dissect and reconstruct different body systems throughout the term, relating the anatomical structure to the physiological functions of the body systems, and to visualize and think about how the different body systems are interrelated in homeostasis and environmental or behavioral adaptations. The 3D imaging technology allows students to view normal and irregular anatomy from various planes of section commonly used in medical imaging and discuss the physiological implications of the irregularities. The 3D printed anatomical anomalies (e.g., double aortic arch, brain tumor) were integrated into clinical case studies that the students were required to “solve.” All 3D imaging and 3D printing case studies were based on actual patient data.

As discussed in the presentation, the 3D technologies were integrated into the educational experience as part of the redesign of courses. In planning these changes, major consideration was given to the following elements of the student educational experience: knowledge and skill acquisition, engagement in real-world science issues, promoting teamwork, and professional development and preparation. These changes are based on studies from graduated college science students, indicating the more educationally valuable and successful aspects of their science training (17, 25), and skills anticipated by employers as being particularly relevant and valuable (3). The 3D technologies were specifically chosen because of the advances of their...
use in professional training and real-life settings, such as 3D simulated surgical training (21, 22) and 3D printing of human joints to create customized joint replacement parts with the aim of promoting better surgical and rehabilitation outcomes (1).

The speaker has utilized all three technologies in her courses during the past 2 academic yr and continues to refine the implementation of these technologies based on student feedback (14). A key feature of all three 3D technologies is that they are student directed, as opposed to instructor directed. This means that, while the implementation of each was planned by the instructor, each technology required active participation from the students. Students self-selected into two-person working groups to provide the opportunity for teamwork and adequate time to meaningfully engage with the technologies. All three technologies have been implemented in the laboratory setting, where the time to learn and implement the technologies is available. Furthermore, they were implemented alongside other more traditional “nontechnology” laboratory modalities, such as experiments and dissections, with students rotating through each modality, so that equal experience in each modality was gained throughout the term.

The current outcomes of these technology implementations are encouraging, but not without challenges. Students find that learning how to use the technologies is an initial limitation. Limited data collection to date shows that there is no significant difference in the overall satisfaction between traditional and technology methodologies; however, the more complex or challenging the intellectual content to be learned, the more students appear to prefer nontechnology educational resources to initially learn the information. Student feedback on the 3D printing is encouraging: because the students can see the actual anomalies, it helps them better understand the anatomical issues and better appreciate the physiological implications (14). During the IUPS conference presentation, 3D printed models of some of the anatomical anomalies used in the course were passed around the audience, and general audience feedback indicated interest and excitement about the “hands-on” aspect. Further assessment of these implementations is planned to better understand the value to the student educational experience.

Combined Use of Educational Games and Quizzes in Physiology Teaching, by Fernanda Marcondes

The educational game is an example of active teaching-learning methodology that may increase student engagement, contributing to their learning (9). The association of such games with quizzes is one teaching strategy that allows the formative assessment during the teaching-learning process. The speaker talked about educational games to teach physiology themes that she has developed based on observed students’ difficulties, in particular, the cardiac cycle and membrane resting and action potentials. She explained that the educational games may be competitive or noncompetitive activities, which can be used at the beginning of a class as motivational strategy, after a lecture for reviewing the themes studied, or as a teaching strategy developed as the main activity during a class. She combines the educational games with quizzes, performed with the free mobile application Socrative.

By way of example of this strategy of teaching, the speaker explained that, at the beginning of the class, the students individually complete a quiz that tests their base knowledge that is expected to understand the new topics to be studied. If it is observed that some content should be reviewed, the instructor asks the students to answer the same questions again in pairs or groups of three. By using this strategy, the speaker performs a diagnostic assessment and provides moments for collaborative learning. During the discussion, she solves the doubts of the students.

Next, the speaker described her approach to run a class, for example, on the topic of the characteristics of the cardiac cells in the cardiac cycle. She gives a short lecture explaining basic information about the theme to be studied. The students are requested to read in a textbook the content worked in the classroom and also the content that will be developed with the educational game. In the following class, the students work in groups to organize the figures of the cardiac cycle and then complete a table with chips, indicating the state of atria and ventricles (contracting or relaxing) and valves (opened or closed), and the phases of cardiac cycle. The teacher evaluates and provides immediate feedback. Importantly, the teacher does not indicate what is incorrect. The students are requested to discuss and discover together what should be changed. This promotes deeper learning. During the activity, some questions are also presented for group members to answer orally. The speaker has observed that students understand topics better with this kind of activity than via lecture-only delivery mode.

The combination of the quizzes and games provides a formative assessment and continuous feedback to the students. In the last 2 yr, the speaker started to investigate the effects of the educational games on the knowledge of students. First, the perceptions of students about the cardiac cycle puzzle has been evaluated. According to student feedback, in different institutions and courses, this strategy have been useful to their learning (20). More recently, she coordinated two studies to evaluate the effect of the educational games on the learning of students, by comparing their performance in tests after lecture or activity with the educational games. The results obtained showed that students who had learned the themes with the educational games had higher grades and fewer mistakes in assessment tests, in comparison to students who had learned with lectures (5, 19). The tests were performed some days after the lecture or educational games activity. The speaker also showed some preliminary data about learning retention in students 4–5 yr after studying some of these challenging physiology themes. The data showed that students achieved a higher quiz score on these themes, if their learning had been supported with the use of the educational games compared with lecture-only delivery mode.

Animating Textbook Images: Tackling “Roadblock” Physiological Concepts in the Online Subject Delivery Era, by Colleen Thomas

The third speaker highlighted recent trends for teaching practice in higher education: away from the traditional synchronous “transfer” delivery, and toward a flipped classroom approach using blended (face-to-face and online) and online-only delivery modes (18). In the context of this rapidly expanding online education space, it was noted that the principles of learning remain unchanged (Bloom’s revised taxonomy), but there is an emerging requirement for innovation to link
pedagogy, technology, and learner needs. In particular, technologies available to support student learning should provide a rich and engaging learning experience compatible with different learning styles.

With colleagues, the speaker has previously published evidence for the benefit of including intra-semester online tests to assess physiology theory requiring deeper learning (23). In particular, these activities provide educators with the opportunity to identify students who are at risk of performing below expectations in the end-of-semester examination. In this presentation, the speaker highlighted her work assisting student online learning with “roadblock” topics in physiology. Whereas the cardiac cycle is a fundamental concept for undergraduate physiology students to grasp, many educators could attest that it is also the one with which students most struggle in the cardiovascular syllabus. This is a medium-complexity learning activity with challenging and dynamic concepts that are difficult to represent in text and static images. The requirement to interpret multiple panels of graphs and appreciate simultaneous activity of events governing the generation of a heartbeat and blood flow is daunting for novice learners.

The speaker presented her tips, trials, and tales, making and delivering a “memorable” animation of the textbook image of the cardiac cycle. Embedding customized active learning approaches into the video (e.g., “thought” questions, scaffolding questions and opportunities for reflective practice for student learning) and maintaining alignment with the learning outcomes and the textbook were emphasized. The necessity for high-quality video production values was also stressed. The video asset should be device friendly, including control of speed, close-ups and zooming, use of colors and pointers, time sensitive (<10-min duration each), with students providing favorable comments on their ability to see the instructor (periodic; for authenticity, engagement), rather than only hearing simple narration. Lastly, the speaker indicated the time commitment to produce targeted “rich media” of this nature, but with an emphasis on authenticity, engagement, rather than only hearing simple narration. The speaker indicated the time commitment to produce targeted “rich media” of this nature, but offered that, once made, this video asset had considerable reuse value for delivery into multiple subjects (campus courses and online only courses). The speaker provided qualitative data from students indicating the online videos were engaging and helpful in understanding the topic.

*Brain Awareness Week as a Teaching Tool, by Kathleen Bartlow*

Undergraduate-directed outreach programs can promote student learning in physiology and neuroscience courses (2, 10, 24), but many obstacles still exist in promoting science outreach (8). Small colleges may be particularly affected by difficulties in budgeting for outreach materials, finding space to host outreach activities, and coordinating the schedules of undergraduate students with students and teachers in the K–12 classroom. The speaker found a novel way to circumvent these limitations by working together with colleagues at a natural history museum (Joseph Moore Museum, Richmond, IN) to develop an outreach program for Brain Awareness Week. This project had the additional advantage of permitting undergraduates to form interdisciplinary collaborations between science students and student workers in the museum. Interdisciplinary teaching is considered a best practice in teaching undergraduate biology, as it broadens the perspectives of all students involved in the project and further allows the science students to gain experience working in diverse teams to solve a problem (4).

The program developed by the speaker and her colleagues is ~3 mo in duration and could either be integrated into the physiology/neuroscience curriculum or run as an extracurricular opportunity. Students in the biology and neuroscience majors work in small groups to develop an idea for a museum exhibit, explaining a concept within neuroscience. The student groups meet regularly with museum staff and with student workers in the Museum Studies program. The museum staff and students are able to offer feedback and provide suggestions as to how the biology/neuroscience students might improve their communication with the public. The program culminates in the biology/neuroscience students presenting their exhibits and demonstrations in the museum on a weekend day in March, thereby avoiding class scheduling conflicts.

Some early qualitative data indicate that students felt that this program aided their scientific development. Almost every student reported improved public speaking skills, and most students wrote that the program helped them master neuroscience course content. Early data also indicate that students who volunteer to participate in the program are more likely to express confidence in public speaking. This might indicate that less-confident speakers should be strongly encouraged to participate, or that outreach should be incorporated into the curriculum, as the students most in need of interventions to improve their confidence in public speaking are less likely to choose to participate in these interventions. Confidence in public speaking should be fostered while training future scientists, as most working scientists perform outreach activities but have low confidence in their own and their peers’ abilities to communicate with the general public (8, 15).

The speaker also addressed other potential strategies for educators to form interdisciplinary partnerships to improve students’ abilities to communicate their science to the general public; for example, pairing physiology students with art students to create artwork celebrating physiology, with the underlying scientific concepts explained in the artist’s notes for each piece.

*Using Virtual Platforms and Audience Response Systems to Engage Students in Learning and Understanding Physiology, by Maria José Alves Rocha*

The last speaker talked about the necessity to think about new ways to engage millennial students (born between 1982 and 1996) and the more recent generation Z of students (1996 to present) for whom computers are no longer technology, but part of their lifestyle (11). Since students expect us to incorporate information technology in their courses, how should we use it as a “partner” in teaching and learning strategies? In this presentation, the speaker talked about virtual platforms, such as Moodle (Modular Object Oriented Distance Learning), and its interesting resources (blogs, wikis, forums, chats, quizzes, and others), and how she enthusiastically used it once it was incorporated in the website of her institution. Moodle was used to assist in lecture delivery (PowerPoint), videos, case studies, and, especially, quizzes for formative assessment. In the beginning, the platform was considered interesting by the students; however, the interest decreased over time. One probable
cause is that only a few teachers adopted its use. Nevertheless, the speaker keeps using the platform for class work assignments and quizzes for formative and summative assessments.

Next, the speaker talked about another interesting resource, the Audience Response System (ARS). Some ARSs use devices known as clickers, which consist of small electronic transmitters, similar to remote controls. Professors formulate questions that can be presented during class. The students can then select among possible responses using the device. The results are transmitted to a receiver connected to a computer and can be immediately displayed on screen. The advantages of this type of technology include the following: high acceptance and enthusiasm from students, anonymity of responses, instantaneous feedback that help monitor how and what the students understood, and little need for physiology instructor ARS training and technical support. Her institution began using the clickers in 2014, but, once again, it was by only few teachers. Two studies have already evaluated the use of these devices in her institution. One study showed that the students strongly agreed that clickers help them to pay attention in the lectures and improved understanding of the learning content.

The other study evaluated the impact on student performance and found no difference between using or not using the device in the classroom (6). Interestingly, when comparisons were made between the use of clickers (anonymous) vs. hand-raising (not anonymous), the participation in answering questions was higher in the clickers group, whereas unanimity in the answers was higher in the hand-raising group. The perception of the students, evaluated through a questionnaire, was that the use of clickers increases attention, participation, interest in the topic, and learning. The reasons for their minimal use by the teachers indicated anxiety that the technology may have failures and the expected time needed by the instructor to learn or prepare the technology. The speaker pointed out that, currently, free online applications for cellular phones are available and can be used in the same way as clickers, and she described the advantages and disadvantages of using cell phone vs. clickers. Finally, she concluded that technology helps to engage students, encourages individual learning, and, at the same time, facilitates peer collaboration and preparing the students to be work ready. However, she cautioned that technology is always changing and cannot be everything in education. Therefore, one has to have in mind that a successful class will always rely on a good relationship between students and teachers.

After the presentations, the audience contributed with lots of questions and comments addressing all of the talks, further enriching the symposium. Specific comments were made in relation to methods discussed by the speakers. These included questions about the games’ rules and implementation, and how to access them, the cost of the 3D printers (initial and ongoing), access to Socrative, and others. A common question was about the balance of lecture and active methods use, and a frequent concern was about the amount of content that physiology courses have to include. In fact, the symposium needed to be concluded with many delegates still raising discussion points and wishing to share their own experiences. Another activity was scheduled for the room, so conversations and interactions between the audience and the speakers continued outside afterwards. We believe that this symposium contributed to advances and insights in physiology education research, but, more important than this, that it contributed to inspire and motivate the participant physiologists to improve their teaching. A number of participants asked for details of methods discussed, demonstrating the expectation to implement some of them in their classes. Physiology graduate students declared their motivation and the value of discussing more topics like these during their formation as physiologists.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS


REFERENCES


