Harnessing the power of an online teaching community: connect, share, and collaborate

Marsha Lakes Matyas and Dee U. Silverthorn

1Education Office, American Physiological Society, Bethesda, Maryland; and 2Dell Medical School, University of Texas at Austin, Austin, Texas

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IN THE 1990S, the American Physiological Society (APS), like most organizations, was exploring ways to support members and trainees via online resources and programs. Online communication was still primarily accomplished via e-mail, listserves, and websites, although discussion boards and social media were growing in popularity among researchers and educators. Thinking of these interactions as true online “communities” was, in most cases, fodder for computer scientists, editorialists, and hopeful projections for the future (2, 4). As our facility with online communications grew, our demand and need for regular online communication with colleagues became essential. Bulletin boards became discussion forums, social media fostered collaborations and professional networks, and websites became interactive sites to share research ideas, methods, and results. We began calling groups of people who interact regularly “online communities.”

Anyone who has ever written or read a customer review at an online store such as Amazon, Macy’s, or eBay has participated in a “community of transaction” by seeking information from other consumers to make a decision about buying a product (5). Seeking information, advice, or simply a connection with others who share a similar life experience (illness, retirement, aging, job hunting, etc.) involves participating in a “community of relationship” (5). As researchers or educators, we are most likely to seek out “communities of interest” (5) or, more specifically, “communities of practice.” Wenger et al. (10) described these communities as follows:

Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis. These people don’t necessarily work together every day, but they meet because they find value in their interactions. As they spend time together, they typically share information, insight, and advice. They help each other solve problems. They discuss their situations, their aspirations, and their needs. They ponder common issues, explore ideas and act as sounding boards. They may create tools, standards, generic designs, manuals, and other documents or they may develop a tacit understanding that they share. However, they accumulate knowledge, they become informally bound by the value that they find in learning together. This value is not merely instrumental for their work. It also accrues in the personal satisfaction of knowing colleagues who understand each other’s perspectives and of belonging to an interesting group of people. Over time, they develop a unique perspective on their topic as well as a body of common knowledge.

practices and approaches. They also develop personal relationships and established ways of interacting. They may even develop a common sense of identity. They become a community of practice.

For more than a decade, APS has been building the framework for a community of practice for science education and physiology education. As described below, this framework incorporates teaching resources, professional development, educational research, and network building.

Building a Digital Library

The first step in building a community of practice was creating a robust digital library of teaching resources. It was originally initiated in 1997 as a project of the APS Education Committee. Committee member John Dietz (University of South Florida College of Medicine) proposed creating a webpage where APS members could share teaching resources that they had developed; the first page was posted in 1998 with a handful of teaching resources. As shown in Fig. 1, this single-page listing of resources was launched in the same year as the first Google search engine. APS members were encouraged to submit additional resources. As part of her 1999 Orr E. Reynolds Education Fellowship, Education Committee Chair Barbara Goodman (University of South Dakota Sanford School of Medicine) developed review criteria and procedures and recruited a review committee spanning all areas of physiology.

The list of resources grew slowly, but the overall concept of digital libraries was developing rapidly. The National Science Foundation (NSF) called for proposals to establish full, database-driven, digital libraries in all science, technology, engineering, and mathematics areas with standardized metadata that could be shared with a National Science Digital Library (8). With support from the NSF, APS partnered with the American Association for the Advancement of Science and 10 other professional societies to develop a common metadata schema, create individual society digital libraries, and launch a central portal in 2003 where all 12 collections could be searched simultaneously. The resulting portal, BioSciEd Net (BEN; www.BioSciEdNet.org), today provides 20,000+ peer-reviewed resources from >25 life science organizations (including APS) and covers nearly 80 life science areas. BEN metadata is shared with the National Science Digital Library, bringing thousands of educators to the APS digital library each month. As a result of this initial collaboration, the APS digital library, the Archive of Teaching Resources (Archive), was launched in 2003 as a searchable digital library, sharing metadata with both the BEN portal and National Science Digital Library (Fig. 1). Key features of the library included:
• Free access to all users. Anyone could search and use the resources at the library without registering. However, those who registered had additional options, such as saving, sharing, and submitting resources.
• Peer-reviewed resources. All items in the Archive were peer reviewed for scientific accuracy at the time of submission and for appropriate use of humans or animals, if applicable. Because of the diversity of resources and the variety of ways in which they were used, resources were not reviewed for best pedagogy or usefulness.
• Robust search features. All items could be searched by title, description, discipline, keywords, specific pedagogies, grade levels, and resource type (e.g., graphic, video, etc.).
• Robust save and share features. Users could create folders for storing resources and sharing them with colleagues and download widgets to display resources easily on their web-pages.
• Online peer review system. Reviews could be assigned and done online.
• Alignment with national standards. Professional school level items were catalogued and searchable by the APS/Association of Chairs of Departments of Physiology Medical Physiology Learning Objectives (1). K-12 items were catalogued and searchable by National Science Education Standards (6a).
• Inclusion of APS free access journals. Articles from Advances in Physiology Education and Physiology were catalogued as well as selected articles from The Physiologist.

Adding partners. As more users discovered both the Archive and BEN sites, it was clear that a more robust collection of resources would meet the needs of a wider audience of educators. Both the APS Council and the APS Education Committee [under the leadership of Robert Carroll (East Carolina University School of Medicine) and Thomas Pressley (Texas Tech University Health Sciences Center)] were supportive of and instrumental in expanding the scope of the Archive to

![Graph showing the growth of the Archive and BEN sites](http://advan.physiology.org/Downloadedfrom/fig1.png)

Fig. 1. Illustration of the growth of the number of internet sites, the number of Archive of Teaching Resources (Archive)/Life Science Teaching Resource Community (LifeSciTRC) registered users, and the number of Archive/LifeSciTRC resources from 1993 to 2015. Key additions to the Archive/LifeSciTRC resources and partners are noted as well as launches of significant internet sites. Internet growth data were used with permission from Internet Live Stats (https://www.internetlivestats.com). APS, American Physiological Society; IUPS, International Union of Physiological Sciences; NSF, National Science Foundation; HAPS, Human Anatomy and Physiology Society; SDB, Society for Developmental Biology; NAHSEP, National Association for Health and Science Education Partnerships; AAA, American Association of Anatomists; MSMR, Massachusetts Society for Medical Research; NWABR, Northwest Association for Biomedical Research; PECOP, Physiology Education Community of Practice; TPS, The Physiological Society; GSA, Genetics Society of America; ASPB, American Society for Plant Biology.
include broader areas of science. With additional support from the NSF, the following new partner organizations joined the Archive and expanded its resources between 2004 and 2014 (Fig. 1):

- Society for Developmental Biology (2005)
- National Association for Health and Science Education Partnerships (2007)
- American Association of Anatomists (2011)
- Massachusetts Society for Medical Research (2011)
- Northwest Association for Biomedical Research (2011)
- American Society for Plant Biology (2014)
- Genetics Society of America (2014)
- The Physiological Society (2014)

As of June 2015, the digital library contained nearly 7,500 peer-reviewed teaching resources, including multimedia, lesson plans, readings, and resources. The most common resource types are shown in Table 1. All resources are free except for a small subset of American Association of Anatomists resources requiring journal subscription for access. Many resources have been contributed by users; individuals contributing resources retain copyright and control of those resources.

### Supporting Communities of Practice

In 2011, APS began creating tools at the Archive that could truly support a community of practice with increased interactivity among users, research and teaching collaborations, community recommendations of best resources, and community-developed collections to support best practices in teaching and learning. In 2014, the APS Archive of Teaching Resources was relaunched as the Life Science Teaching Resource Community (LifeSciTRC; www.lifescitr.org) to reflect the change in focus (Fig. 1).

Users were encouraged to update their user profiles to include the specific courses they were teaching. This allows LifeSciTRC to offer personalized recommendations. For example, those who teach medical school physiology get recommendations of items that are rated highly by other medical physiology instructors. Communities are forming around both educational levels and topics including K–12 science education, undergraduate life sciences education, and professional/publication ethics. The following new tools engage users in not only getting resources from the digital library but sharing their resources and expertise with their communities of practice:

- Community pages with news and recommended teaching resources. These may focus on themes, upcoming meetings, or specific issues relevant to that teaching community.
- Blogs focusing on classroom and science topics relevant to educators. The “K–12 Confab” was the first blog launched, and topics have included flipped classrooms, next-generation science standards (7), virtual classrooms, and teacher evaluation. More than 20 posts on science and education topics have generated discussion over the past year.
- Forums for educator-led discussions. Community members can initiate conversations on any topic of interest. Users can ask for conversation updates by e-mail on a posting, daily, or weekly basis.
- Resource rating and commenting areas. These allow educators to share their experiences of using resources. User ratings are of especially high value. They highlight the most useful resources to the specific teaching community. Comments detail how educators used a resource and, in many cases, how they modified it to match the needs of their classrooms. For example, Patricia Clark’s highly rated undergraduate lecture review homework assignment, “Cancer: Good Cells Gone Bad” (3), has ratings and comments from a high school teacher who discusses how he adapted it for use with his class and from an college faculty member who used it in a joint undergraduate/graduate cancer biology class.
- Online “badges” to recognize community member contributions (rating, reviewing, discussing, submitting, sharing, etc.).
- Monthly e-newsletters highlighting community members, news, and teaching resources.

As another major addition was the ability to build, share, search, and save collections of items. While each item must be

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Table 1. Most common Life Science Teaching Resource Community resource types by major category

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multimedia</strong></td>
<td></td>
</tr>
<tr>
<td>Digital presentations (e.g., PowerPoint)</td>
<td>1,830</td>
</tr>
<tr>
<td>Images</td>
<td>1,474</td>
</tr>
<tr>
<td>Illustrations</td>
<td>1,056</td>
</tr>
<tr>
<td>Videos</td>
<td>544</td>
</tr>
<tr>
<td>Online tools</td>
<td>434</td>
</tr>
<tr>
<td>Photographs</td>
<td>394</td>
</tr>
<tr>
<td>Graphs/Charts</td>
<td>318</td>
</tr>
<tr>
<td>Animations</td>
<td>208</td>
</tr>
<tr>
<td>Diagrams</td>
<td>199</td>
</tr>
<tr>
<td>Short movies</td>
<td>125</td>
</tr>
<tr>
<td>Simulations</td>
<td>118</td>
</tr>
<tr>
<td>Tables</td>
<td>97</td>
</tr>
<tr>
<td>Webcasts</td>
<td>84</td>
</tr>
<tr>
<td><strong>Classroom teaching</strong></td>
<td></td>
</tr>
<tr>
<td>Assignments/activities (not hands-on)</td>
<td>764</td>
</tr>
<tr>
<td>Teaching strategies and guidelines</td>
<td>673</td>
</tr>
<tr>
<td>Lesson plans</td>
<td>629</td>
</tr>
<tr>
<td>Laboratories or hands-on activities</td>
<td>602</td>
</tr>
<tr>
<td>Lectures/lecture outlines/lecture notes</td>
<td>215</td>
</tr>
<tr>
<td>Tutorials</td>
<td>165</td>
</tr>
<tr>
<td>Assessments: general*</td>
<td>156</td>
</tr>
<tr>
<td>Study guides</td>
<td>109</td>
</tr>
<tr>
<td>Laboratory manuals</td>
<td>108</td>
</tr>
<tr>
<td><strong>Reading room</strong></td>
<td></td>
</tr>
<tr>
<td>Journal articles/issues</td>
<td>4,359</td>
</tr>
<tr>
<td>Nonjournal articles</td>
<td>839</td>
</tr>
<tr>
<td>Meeting presentations</td>
<td>497</td>
</tr>
<tr>
<td>Newsletters</td>
<td>440</td>
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<tr>
<td>Biographies</td>
<td>355</td>
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<tr>
<td>Press releases</td>
<td>322</td>
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<tr>
<td>Pamphlets/brochures</td>
<td>119</td>
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<tr>
<td>Reports</td>
<td>72</td>
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<tr>
<td><strong>Reference room</strong></td>
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<tr>
<td>Indexes</td>
<td>176</td>
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<tr>
<td>Reviews</td>
<td>162</td>
</tr>
<tr>
<td>Scientific standards and guidelines</td>
<td>80</td>
</tr>
<tr>
<td>Data sets</td>
<td>68</td>
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</tbody>
</table>

*There are multiple categories of assessments; this is the largest group.

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1 The National Association for Health and Science Education Partnerships has since become an inactive organization, but their resources are still available through the digital library.
catalogued separately, educators can now annotate how they use a group of resources from the digital library collection to teach a specific lesson or concept. They describe how they used the resources and what they observed in their classrooms. These “teacher-developed collections” are growing in number and popularity because they represent true colleague-to-colleague sharing. For example, one educator’s collection of resources (11) helps students explore the range of cancer treatments through lecture, readings, podcasts, an interactive simulation, and a writing project. Separately, these are useful resources. As a collection accompanied by the submitting teacher’s annotations, they greatly facilitate the user’s work in replicating her effective lesson and approach. The number of collections is growing rapidly with 264 collections developed in <3 yr.

Communities of Practice in Action

The framework has proven effective in supporting the development of multiple communities, both national and international, and continues to encourage the development of new education groups and communities. The examples below describe critical methods for promoting connection, sharing, and collaboration among community groups.

The International Union of Physiological Sciences teaching group: building an international community. The importance of electronic communication in facilitating collaboration can be seen in the history of a community of international physiology scientist-educators, the International Union of Physiological Sciences (IUPS) teaching group. One IUPS teaching group project began from interest in developing and improving student laboratory activities and, over the years, has evolved into an active online community sharing resources through multiple outlets. In many ways, the story of the IUPS group’s laboratory activities project parallels the development of the internet, e-mail, and social media.

The IUPS community of physiology educators formed at a teaching workshop that preceded the 1986 IUPS Congress in Sydney, NSW, Australia, and in 1989, at a teaching workshop in Kuopio, Finland, associated with the IUPS Congress in Helsinki. It was at the Kuopio workshop that a breakout group on the role of laboratory exercises in physiology recommended creating a forum for sharing information on laboratory work and new techniques, evaluating laboratory activities, and identifying sources of economical equipment (9).

In 1989, international communication was mostly by air mail or very expensive international phone calls, making a true interactive community impossible. Time differences made synchronous communication very difficult, but asynchronous communication online was not commonplace yet. The internet was still in its early phases, expanding but far from being a common means of everyday communication. In 1989, there were only ~100,000 hosts (computer systems with registered IP addresses) worldwide (3). For comparison, by late 2013, there were a billion hosts.

Despite their difficulties with communication, the IUPS community managed to be successful. In 1990, the IUPS Education Committee published a small book, A Source Book of Practical Experiments in Physiology Requiring Minimal Equipment (2). The original Source Book was a print volume and very expensive to purchase, which made it difficult to achieve the goal of making the contents widely available.

Only 7 yr later, in 1997, internet use had exploded. There were nearly 20 million registered hosts (Fig. 1), and e-mail had become a common means of communication in academic settings. Planning for the 1997 IUPS Teaching Workshop in Repino, Russia, was done by an international planning committee with members from the United States, Canada, Australia, and Russia. Laboratory equipment itself was also evolving, from oscilloscopes and ink-and-paper chart recorders to the first generation of computer-based data-acquisition systems, such as Maclab. However, global penetration of the internet was still incomplete, and IUPS colleagues from developing countries reported erratic connectivity and limited access to hardware.

It was at the 1997 IUPS meeting that the teaching group decided to create a second edition of the Source Book of Practical Experiments in Physiology Requiring Minimal Equipment. Initial planning for the revision took several years. The group hoped to make revisions to the existing book and post the revised work on a website, but the publisher, who also held the copyright, refused to grant the necessary permissions. At this point, a new vision was needed.

The increasing access worldwide to e-mail service increased the IUPS community’s ability to share and collaborate. E-mail exchanges, facilitated by the creation of an IUPS Teaching Listserv in 1999 by Adrianta Surjadihana of the Airlangga School of Medicine in Indonesia and some limited face-to-face meetings at non-IUPS teaching workshops led to a new plan of action. The group would create a new sourcebook designed for electronic dissemination. In 2003, a subset of the IUPS group submitted a proposal for development of the new sourcebook, now called the 21st Century Project, to the NSF. The supporting personnel included educators from 18 countries, all members of the community that had developed the initial idea for the project.

In 2004, the grant, entitled “Physiology for the 21st Century: a Sourcebook of Effective and Economical Experiments,” was funded (Fig. 1). At the time the grant was written, the state-of-the-art dissemination plan was to turn the activities into downloadable files in rich text format (*.rtf) that could be shared with the IUPS teaching community and with educators worldwide from a dedicated APS website and via compact disk that could be mailed through the postal service or handed out at meetings.

Draft documents were often too large for international collaborators to receive via e-mail; therefore, a webpage was established to allow collaborators to share drafts and guidelines via download/upload. The 2005 IUPS Teaching Workshop, held at Pali Mountain, CA, provided an opportunity for the second generation of sourcebook collaborators to meet face to face for planning. A working group of 35 physiologists spent 3 days developing a template for the new sourcebook. One shortcoming of the original exercises was lack of detail, so the new activities were to be a detailed resource from which instructors could create inquiry-focused laboratories designed to fit their learning goals and student population. Workshop participants went home with plans to work on their individual contributions.

By the time the first activities were ready for submission, communication and collaboration modes had changed again.
As described above, the Archive came online. The need for a special APS website or distribution of *.rtf files disappeared. The first two IUPS sourcebook activities were submitted to the Archive, and additional activities for the Sourcebook of Laboratory Activities are being published in the APS online education journal Advances in Physiology Education (also catalogued in the Archive).

The sourcebook project had broad impacts. Not only had this multinational teaching group created new teaching resources and made them freely available to the broader international community, but they established a model for future international collaborations and publications. At the 2009 IUPS Teaching Workshop in Kobe, Japan, educators shared not only what they were teaching and how but also how they were assessing the effectiveness of their teaching. Discussions about research and evaluation collaborations that started during meals in Kobe continued after the meeting via the IUPS listserv, e-mail, and Skype. The effects were evident at the next IUPS Workshop in Bristol, England, in 2013. The posters and presentations were rich with data from evidence-based teaching and educational research, and many represented collaborative projects across two or more nations. The IUPS teaching community was transforming to an international community of practice embracing excellence in both teaching and educational research.

Physiology educators in many countries still face significant barriers to active international collaborations, including restricted travel, limited internet access, and even limited electrical power access. Yet the connections, sharing, and collaborations that serve as the foundation of this international education community of practice continue to grow and foster its contributions to excellence in physiology education worldwide.

The Physiology Education Community of Practice. In 2014, with support from the NSF (6), APS launched the Physiology Education Community of Practice (PECOP) to support all those who teach physiology (Fig. 1). The community was launched in conjunction with the first APS teaching conference, the 2014 Institute on Teaching and Learning (ITL) in Bar Harbor, ME, and the first APS Professional Skills Training (PST) course on “Becoming an Effective Teacher.” PECOP encompasses multiple teaching levels (K–12, undergraduate, graduate, and professional), includes international and novice educators, and promotes strong participation by faculty members at institutions serving underrepresented students (underrepresented minorities, persons with disabilities, and persons from disadvantaged backgrounds). The ITL and PST courses benefitted the PECOP launch by serving as:

- A forum to begin building the PECOP structure and management and recruit participants, encouraging educators to interact, share resources, and collaborate on an ongoing basis, and
- An opportunity for physiology educators to learn “best practices” in physiology education and how to use scholarship of teaching and learning methodologies to improve their teaching.

PECOP development is being led by two groups of physiology educators. Thought Leaders are experienced physiology educators. They guided discussions at the ITL and are continuing these discussions online through blogs and discussions on key topics such as curriculum development, student-centered learning, assessment, effective undergraduate research experiences, and scholarship of teaching and learning methods. The second group, PECOP Fellows, includes undergraduate faculty members who will:

- Increase their knowledge of effective scientific teaching methods and how to apply them in their classrooms.
- Become active members of the LifeSciTRC as contributors, raters, reviewers, and bloggers.
- Explore scholarship of teaching and learning and how it can contribute to effective classroom teaching and be able to describe ways to contribute to our understanding of teaching and learning by both formal and informal sharing with colleagues.
- Develop ongoing relationships with each other, with Thought Leaders, and with other members of the PECOP community to support excellence in teaching and learning.

Many PECOP Fellows are faculty members at institutions serving underrepresented students.

How will PECOP affect the quality of teaching and learning in physiology classrooms? First, PECOP will share information and encourage physiology educators to use best practices, that is, evidence-based teaching methods that are proven effective at promoting students learning in physiology classrooms. Second, PECOP will encourage educators to share their observations on how those methods work in the broad range of their classes and student bodies through in-person and online discussions of posters at Experimental Biology meetings and articles in teaching magazines and journals (e.g., Advances in Physiology Education’s “Illuminations” section). Finally, PECOP will encourage physiology educators to contribute to the knowledge base of “what works” by collaborating on educational research projects and publishing in peer-reviewed education journals. Toward this end, one of the first PECOP bulletin boards is devoted to developing and supporting research and teaching collaborations.

New Communities

Additional communities are finding homes at LifeSciTRC as groups and topics move forward and interest grows. A group of >20 scientific society education staff, the Professional Society Alliance for Life Science Education uses LifeSciTRC as a “home base” for its discussion boards. Most recently, a group of undergraduate faculty members launched the Physiology Majors Interest Group, a consortium of undergraduate programs in physiology. The LifeSciTRC community tools will provide a forum for dialogue on best practices for undergraduate physiology programs.

Hillary Clinton cited an African proverb, claiming that it takes a village to raise a child (12). Communities of practice suggest that it also takes a village to effectively teach a child. The APS education communities have the potential to promote the use of best teaching practices, expand our understanding of teaching and learning through research, and support new educators as they begin their careers. We invite all those who teach to participate in these communities. Register at www.lifescitr.org or contact the authors for more information.

DISCLOSURES

Matyas is employed by the American Physiological Society and is the senior manager of the Life Science Teaching Resources Community.
AUTHOR CONTRIBUTIONS

Author contributions: M.L.M. conception and design of research; M.L.M. performed experiments; M.L.M. and D.U.S. analyzed data; M.L.M. and D.U.S. interpreted results of experiments; M.L.M. prepared figures; M.L.M. and D.U.S. drafted manuscript; M.L.M. and D.U.S. edited and revised manuscript; M.L.M. and D.U.S. approved final version of manuscript.

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