

COMMENTARY-PROFESSIONAL DEVELOPMENT

Publishing activities improves undergraduate biology education

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One sentence summary: To improve undergraduate biology education, there is an urgent need for biology instructors to publish their innovative active-learning instructional materials in peer-reviewed journals.

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ABSTRACT

To improve undergraduate biology education, there is an urgent need for biology instructors to publish their innovative active-learning instructional materials in peer-reviewed journals. To do this, instructors can measure student knowledge about a variety of biology concepts, iteratively design activities, explore student learning outcomes and publish the results. Creating a set of well-vetted activities, searchable through a journal interface, saves other instructors time and encourages the use of active-learning instructional practices. For authors, these publications offer new opportunities to collaborate and can provide evidence of a commitment to using active-learning instructional techniques in the classroom.

Keywords: education; active-learning; undergraduate; teaching collaboration

INTRODUCTION

Using active-learning instructional techniques increases student learning and decreases the failure rate in STEM classes (Freeman *et al.* 2014). As a result, several reports have called for a revolution in how undergraduate biology is taught, moving away from a lecture-only approach to one in which students are engaging in problem-solving activities, having peer discussions and asking authentic questions in the classroom (AAAS 2011; President's Council of Advisors on Science and Technology 2012; European Commission High Level Group 2013; National Research Council 2013). Many biology instructors are answering these calls by developing new classroom activities and evaluating their quality through assessments of student learning.

To develop new classroom activities, biology instructors often collect evidence about student conceptual difficulties using a variety of response validated assessment instruments (Smith, Wood and Knight 2008; Nehm *et al.* 2012; Paustian *et al.* 2017), develop instructional materials and assessment questions that address the conceptual difficulties, collect evidence about

student learning and make iterative revisions. For example, a group of instructors from multiple institutions asked their students about the impact of a premature stop codon on DNA replication, transcription and translation (Prevost, Smith and Knight 2016); learned that many students had a mixed understanding of the central dogma of biology; developed an active-learning case study activity that addressed the identified conceptual difficulties; and measured improvement in student learning using multiple assessment questions (Pelletreau *et al.* 2016).

Arguably, developing classroom activities results in important intellectual contributions that are an indication of a commitment to using evidence-based active-learning teaching techniques. This commentary encourages biology instructors to publish their activities in peer-reviewed journals such as FEMS Microbiology Letters (<https://academic.oup.com/femsle/issue/363/16>), CourseSource (<https://www.coursesource.org/>) and the Journal of Microbiology and Biology Education (<http://www.asmscience.org/content/journal/jmbe>). These publications can be used to help other instructors overcome barriers to using

active-learning, afford an opportunity to collaborate with colleagues on issues of teaching and learning and provide documented evidence for scholarly activities around teaching.

PUBLISHING ACTIVITIES PROMOTES ACTIVE-LEARNING

Classroom observation data and faculty surveys indicate that, while on the decline, lecture is a predominant instructional behavior in undergraduate classrooms (Eagan 2016; Manduca et al. 2017; Stains et al. 2018). When undergraduate instructors are asked about barriers to incorporating active-learning into their classrooms, they often talk about a lack of time, incentives and professional development opportunities (Silverthorn, Thorn and Svinicki 2006; Henderson and Dancy 2007; Brownell and Tanner 2012). Having access to high-quality activities would minimize some of these barriers and could help more instructors get to a place where teaching with well-vetted active-learning activities is the norm in undergraduate biology classrooms.

One option currently available to instructors is to search biology concepts of interest on the internet, such as microorganism replication, and explore the activities that exist. However, sorting through the activities takes time and because it is rare to get peer review on instructional materials, it can be difficult to determine which activities will be successful. Furthermore, there are often errors, directions that are difficult to follow and links that have not been updated. Instead, if instructors could search journals with peer-reviewed biology activities that have been taught in undergraduate classrooms and are searchable by key concepts, chances are higher that they would find activities with fewer errors, more evidence of student learning and materials that are ready to use or easy to adapt. Currently, many journals are eager to expand the activities they publish and view their role as coaches in the peer-review and publication process (Blum et al. 2018).

DEVELOPING PUBLISHABLE ACTIVITIES ENCOURAGES NEW COLLABORATIONS

Scientific research collaborations are ubiquitous, critical to discovery and a celebrated part of the field (National Research Council 2015). Moreover, these benefits can extend to teaching collaborations where colleagues develop activities and publish their findings. Together groups of instructors can collect evidence about student conceptual difficulties, share experiences and ideas, write activities and assessment questions, collect evidence about student learning, make iterative revisions and publish their findings (Pelletreau et al. 2016; Smith et al. 2018). Furthermore, recent work has shown that when faculty collaborate on the development of an activity, teach it in their classrooms, and co-author a publication, they are more likely to use active-learning instructional techniques (Pelletreau et al., 2018).

There are a variety of ways to find collaborators. Instructors can often collaborate with colleagues at their institution who teach the same course at a different time or teach courses that come before or after their courses. Teaching collaborators also frequently meet at professional development events. For example, participants in the Summer Institutes on Scientific Teaching learn about active-learning, assessment and inclusive teaching in a week-long immersive professional development institute (Pfund et al. 2009). The participants also develop a 'Teachable Tidbit'—an instructional unit to be used at their home institution (Wood and Handelsman 2004). Several groups of instructors have taught their Teachable Tidbits, made iterative

changes based on student learning data and published manuscripts (Hoskinson et al. 2014; Sestero et al. 2014; Emtage et al. 2016; Freeman et al. 2017). Professional society meetings are also great ways to start teaching collaborations. Often there are roundtable or 'dine and discuss' events where developing activities can be the focus of the conversation.

Publishing activities also offer an opportunity to collaborate with graduate students and postdocs. The chance to design and publish activities can provide pedagogical training that is often highly sought after by graduate students and postdocs (Bok 2013), and help prepare them for a variety of careers that often include teaching. Publications about instructional activities can enhance curricula vitae, provide evidence of excellence in teaching, help prepare for the teaching demonstration portion of academic interviews (Smith, Wenderoth and Tyler 2013) and be used as examples in teaching philosophy statements that are often requested in job applications.

PUBLISHING ACTIVITIES IS EVIDENCE OF A COMMITMENT TO HIGH-QUALITY TEACHING

Recently, there have been several movements to rethink the way teaching effectiveness is evaluated for faculty at the undergraduate level (Sursock 2015; Dennin et al. 2017). Notably, there are generally agreed upon metrics for evaluating research success such as the number and prestige of journal articles and the value of awarded grants. But evaluating teaching expertise can be more difficult because there are fewer quantitative metrics and ones that are commonly used, such as student teaching evaluations, are subject to bias and not necessarily tied to student learning (Centra and Gaubatz 2000; Clayson 2009; Braga, Paccagnella and Pellizzari 2014; Boring, Ottoboni and Stark 2016).

However, if biology faculty publish their activities in peer-reviewed journals, these publications could be used as evidence for effective teaching. For example, instructors can list these publications in the Peer-Reviewed Articles section of their curricula vitae and then report more information about the instructional materials, student learning data and iterative revision process in the teaching section of their tenure and promotion paperwork. Instructors can also consider having someone observe their class when they teach activities they plan to publish using tools such as the Teaching Dimensions Observation Protocol (Hora, Oleson and Ferrare 2013), Classroom Observation Protocol for Undergraduate STEM (Smith et al. 2013) or Practical Observation Rubric To Assess Active Learning (Eddy, Converse and Wenderoth 2015). These observations can provide important data about instructional practices that can be used in the journal publication and as documentation of the use of innovative instructional practices.

Publications about activities could also send a powerful message to prospective students and their families about the value an institution puts on teaching and the types of learning experiences that will occur in the classroom. Departments can highlight teaching accomplishments using similar metrics to research achievements to show how faculty are using student learning data to improve their own teaching and sharing their innovations with a broader audience.

CONCLUSION

Think about your most effective active-learning activities and consider writing them up for publication. Writing the article will help you reflect on the activity, hold you accountable to evaluating its impact on students and likely improve the quality of the

activity for the next time you teach it. Because the writing style is often more similar to a methods paper than a research article, make sure to write about your activities in a way that can be easily replicated by a broad audience. Publishing activities provide benefits to other instructors and the experience may provide an opportunity to form new collaborations centered on teaching. You will also send a powerful message that effective teaching in biology is an important intellectual endeavor that is worthy of being shared and highlighted by your institution.

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