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Guest Editorial

Teaching post-secondary students in ecology and evolution: Strategies for early-career researchers

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Abstract

Teaching can be a rewarding, yet challenging, experience for early career researchers (ECRs) in fields like ecology and evolution. Much of this challenge arises from the reality that ECRs in ecology and evolution typically receive little, if any, pedagogical training or advice on how to balance teaching, research (which can include extended field work), and other demands on their time. Here, we aim to provide accessible, pragmatic advice for ECRs in ecology and evolution who are given the opportunity to teach (as instructor of record). The advice is based on the authors' collective experiences teaching in ecology and evolution as ECRs and is meant to help ECRs address two challenges: a) balancing the demands of teaching against one's research, service, and personal life, and b) being effective in the classroom while doing so. The guidance we provide includes practical steps to take when teaching for the first time, including carefully refining the syllabus (course planning), adopting 'non-traditional' teaching methods, and taking advantage of free teaching resources. We also discuss a range of 'soft skills' to consider, including guarding against imposter syndrome (i.e., self-doubt and fear of being exposed as a fraud), managing expectations, being empathetic, compassionate, authentic, and fostering an inclusive classroom. Lastly, we emphasize the need to focus on developing students' critical thinking skills, integrating research and teaching where possible, and setting limits on class preparation time to maintain balance with your research and personal life. Collectively, we hope the examples provided here offer a useful guide to ECRs new to teaching.

Keywords: pedagogy, faculty, instructor, lecturer, university

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Introduction

Many instructors at post-secondary institutions have little to no formal training in pedagogical theory or practice, and are simply handed the proverbial *keys to the classroom* (Love Stowell et al. 2015, Shortlidge and Eddy 2018). Additionally, at some institutions, it has become common for undergraduates to be taught by graduate students and postdoctoral fellows hired as contract instructors (Bettinger et al. 2016, Pasma and Shaker 2018), which effectively increases the proportion of courses taught by early career researchers (ECRs, here defined as senior graduate students, post-doctoral fellows, and recently hired faculty). To excel in both teaching and research (and service), trade-offs of time and energy can create a 'role conflict' (Hattie and March 1996). ECRs must navigate the classroom with little time or training (Jocoy 2006), while also juggling research and other commitments (Laudel and Gläser 2008).

Each of the authors of this editorial has had varied experiences teaching post-secondary courses (as instructors of record) during the ECR stage in topics related to ecology, evolution, environmental sciences, and animal biology. We have taught students spanning several countries including Australia, Canada, Finland, Switzerland, Sweden, the United Kingdom, and the United States. Practical motivations to teach at the ECR stage can range from financial incentives, to personal interest, to gaining teaching experience in the pursuit of permanent employment, including tenure-track positions in academia. More fundamentally, teaching can help educators and researchers become better communicators of science and deepen their knowledge of topics of interest (Lucas and Turner 2007, Shortlidge and Eddy 2018).

The objective of this editorial is to provide suggestions, based primarily on our experiences, for ECRs in ecology and evolution venturing to the podium of a classroom for the first time. These suggestions include ideas, techniques, and solutions to common challenges, which have been collapsed into eight strategies. As scientists, we value rigorous empirical evidence, yet in our teaching we rely significantly on anecdotal or indirect evidence (e.g., student experience questionnaires, advice from others, personal experiences). There is an important and vast literature on the science of teaching (i.e., evidence-based teaching, Davies 1999, and see Waldrop 2015), that has spawned many books, peer-reviewed articles; part of our goal in this perspective paper is to point readers towards those resources by highlighting examples.

Our aim here is to provide accessibly-written, pragmatic guidance on how to balance the demands of teaching against growing a research program, striving for work-life balance (e.g., family duties, relationships, mental and physical health), and for being an effective educator while doing so. Our perspectives are broadly organized according to two challenges ECRs often face: a) the juggling act (Figure 1) involved in managing the potentially onerous demands placed on ECRs by teaching while facing other pressures on their time, and b) techniques and strategies for delivering effective teaching while performing this juggling act. Although we have strived for broad applicability and relevance in the eight strategies we highlight, we acknowledge that not all of the advice on offer will be applicable to all ECRs, post-secondary courses, or contexts.

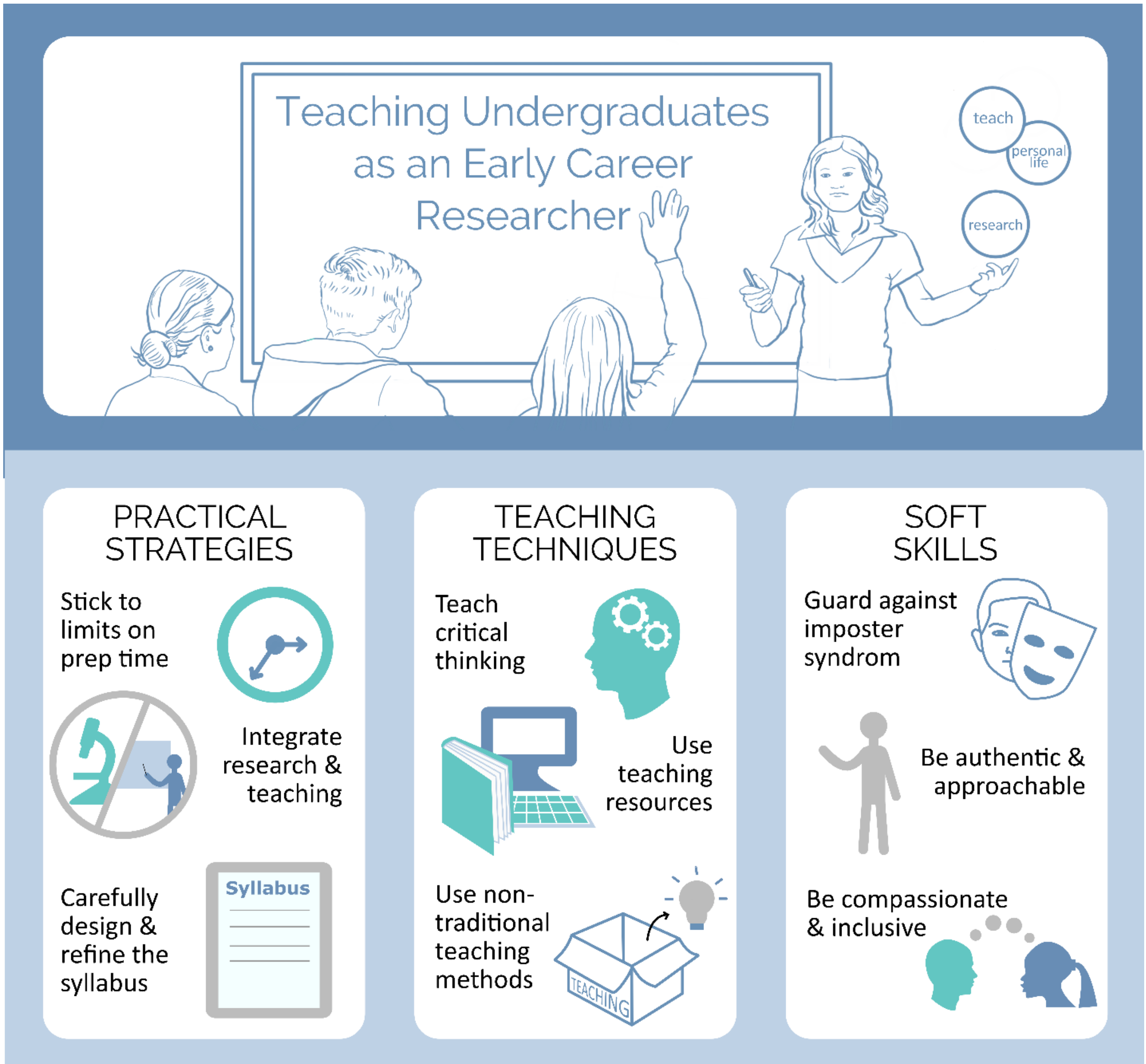

Figure 1. ECRs acting as course instructors for the first time face a difficult balancing act; following some of the strategies summarized here can help. Artistic credit: Sofia Jain-Schlaepfer.

1. Challenge #1: the juggling act—balancing teaching demands against other pressures

1.1 Set realistic expectations for yourself to keep imposter syndrome in check

Your first teaching position is an opportunity to think back on the best and worst teaching you experienced as a student. Courses that are exceptionally engaging and effective take years to develop. Setting realistic expectations can help maintain a positive outlook. For example, when teaching for the first time, having lecture/teaching material is vital, so a primary goal must be to ensure that this material is ready on time (see *section 1.2*). Expectations can be managed by focusing on one or two take-home messages per class rather than cramming in bits and pieces of complex material. We advocate that ECRs strive to continuously re-visit expectations for themselves and their courses as their careers, personal lives, and research change over time.

ECRs are particularly susceptible to self-doubt and fear of exposure (i.e., the imposter syndrome) (Woolston

2016). Given a lack of training in education and difficulty transitioning from specialized research to broader subject matters (Kugel 1993), imposter syndrome may be more acutely felt among ECRs in their roles as instructors than in their roles as researchers. Indeed, many of us have experienced imposter syndrome; the reality is that there is not one easy solution for it. However, you can stifle feelings of doubt by reminding yourself that you have worked hard to be in the position you are in. Talking to colleagues, friends, family, and students can also reduce negative feelings. Being aware of 'triggers' can help you to be proactive. For example, student experience questionnaires (commonly referred to as 'teaching evaluations') are often riddled with biases (recently reviewed by Carpenter et al. 2000) and can be taxing on the emotional wellbeing of instructors (Brems et al. 1994). If critical feedback is a trigger (and feedback can be useful), be mindful when visiting websites such as ratemyprofessors.com! Being aware of the feelings of imposter syndrome and finding ways of facing it are important for managing expectations and overall mental health. Mistakes will be made, and not every assignment or class will go as planned. But that is normal, especially for novice instructors. Failures should be treated as valuable learning opportunities. A key to teaching success is to learn and adapt with the goal of incrementally improving your teaching skills over time.

1.2 Ruthlessly stick to your personal limits on preparation time

It can be tempting to pour several days into perfecting slides for an upcoming lecture, or to dive deep into the literature on a fascinating topic. However, hours spent "over-preparing" for teaching represent an opportunity cost, taking time away from other important aspects of your work and life (research, service commitments, leisure, family, sleep, etc.). We strongly advocate setting your own personal limits on preparation time for a given class and *ruthlessly* sticking to those limits. To be clear, we are not advocating that instructors do the bare minimum, but instead trying to recognize that there is often no clear "end" to lecture preparation. Every instructor prepares differently, resulting in a range of preparation times. The amount of time will depend on a variety of factors, including your familiarity with the material, whether you have pre-existing materials (e.g. borrowed slides, figures from a textbook, videos), the duration of the class, and the amount of time you plan to spend lecturing as opposed to using active learning activities (e.g., think-pair-share; Kaddoura 2013). Across the authors of this paper, we have typically spent between three and eight hours preparing a one-hour lecture (sometimes much less when teaching a course for the second or third time). We have found that sticking to a template for lecture slides and having clear learning objectives for each lecture that align to the course plan can save time and help keep lectures (and students) focused. After class, make a few notes on what worked and what did not (i.e., reflective practice, see Brookfield 1995): many instructors teach the same courses repeatedly, so teaching can be an iterative process.

1.3 Look for time-saving ways to integrate research and teaching

One way to re-think the perceived conflict between research and teaching is to promote the idea of knowledge-building communities, which blur the divide between the production and communication of knowledge (Lucas and Turner 2007). Integrating research and teaching is one way of reducing this perceived conflict while benefiting your students. Research-based learning can facilitate higher-order inquiry, engagement with the material, and communication among students (Heitz and Giffen 2010), but can come with discipline-specific challenges (e.g., making specialized research relevant to broad undergraduate audiences). Research-centered approaches can be adopted inside the classroom (e.g., problem-based learning and case studies) and outside (e.g., field trips and data collection activities). They can also have a practical benefit to you as the instructor by reducing course preparation time. Specific to ECRs in ecology and evolution, research schedules can be imposed by natural phenomena (e.g., reproductive schedules of study organisms, seasonal occurrences) and ECRs typically have a more hands-on role with field work and data collection than do senior principal investigators. Structuring course elements to accommodate inflexible research activities can therefore be an important consideration in syllabus design (see *section 2.2*). Most importantly, integration of research and teaching can benefit students. Hattie and Marsh (1996) argue that 'good' researcher-teachers are "more enthusiastic, have greater breadth of coverage, are more committed to teaching, and appear more knowledgeable"—all of which are desirable attributes for ECRs and instructors. Linking research to teaching helps prepare students to think about and solve complex problems in an age of rapidly progressing science (Brew 2006). Missing an occasional class because of research activities can even create an opportunity to teach students about what caused your absence (e.g., grant selection committees, thesis defenses, data collection) and, when discussed effectively, make you more relatable in the process (see *section 2.4*).

2. Challenge #2: Being an effective instructor while performing the 'juggling act'

2.1 Use institutional training resources and active learning approaches

Training resources may help improve your effectiveness as an instructor and avoid some of the hazards of first-time teaching. While often not overtly advertised to ECRs, many institutions offer online or in-person workshops and other useful resources for instructors and professors at no cost (examples in Appendix Table A1). For example, many universities have 'educational development centres' or similarly named departments that support teaching excellence by providing free tools, online resources, training courses, and consultation with pedagogy experts. Many institutions also provide funds for teaching-related supplies such as laboratory or field equipment. We also recommend investigating whether your institution offers funding for professional development that can be used for pedagogical training or bursaries for additional equipment purchases.

As an ECR with little or no background in teaching, it is *very* easy to get overwhelmed by the literature on the effectiveness of different teaching methods. There is a litany of labels for teaching methods, many of which are related to one another or appear to overlap in the theory underlying their approach. Experiential learning (Kolb and Kolb 2005), flipped classrooms (DeLozier and Rhodes 2017), active learning (Freeman et al. 2014), inquiry-based learning (Lazonder and Harmsen 2016), small-group learning (Springer et al. 1999), problem-based learning (Dochy et al. 2003), and blended learning (Stockwell et al. 2015) each involve non-traditional approaches to teaching. This is where teaching experts at your institution will likely be able to help, in part, by helping to design active learning techniques that fit a given course. Active learning (e.g., Freeman et al. 2014, Januchowski-Hartley et al. 2018) encourages students to think, learn, and engage with one-another and the course material in ways that involve active interaction rather than passive reception of knowledge. Well designed and delivered lectures can be effective for many students, but evidence and opinion among experts on the effectiveness of lecturing is mixed (Goffe and Kauper 2014, Hora 2014). On the other hand, there is clear evidence about the benefits of active learning (Freeman et al. 2014). Specific to ecology, Nordlund (2016) provides a brief, accessible, and practical guide for integrating active learning and diverse assessment tools into course design, with many useful examples.

2.2 Carefully design and refine your course syllabus

A key responsibility for a new instructor is to develop a clear and concise syllabus (see Slattery and Carlson 2005) and to adhere to it. This is an underestimated but crucial step in the preparation phase of teaching that can ensure a smooth experience for the instructor and students. A syllabus is a formal contract between instructor and students that outlines expectations. The most important sections of the syllabus are the course objectives and learning outcomes; every aspect of the course should serve the objectives and outcomes in ways that are clear to students, (i.e. constructive alignment, Biggs 2014, Slattery and Carlson 2005). Chief among these aspects are the assessment components (i.e., how students are graded). Assessment methods should be given careful thought in terms of their effectiveness for learning (for examples of diverse, evidence-based assessment techniques, see Nordlund 2016). Choosing assessment methods should also involve consideration of the burden they will place on the students and instructor(s) and may benefit from consult-ation with experts (*section 2.1*). Providing students with well-defined assignment deadlines and grade break-downs at the beginning of the semester (via the syllabus) ensures that you do not have to spend excessive amounts of time reiterating the minutia of each assignment.

Throughout a course, and during syllabus design, consult guidelines from the literature (Matejka and Kurke 1994, Slattery and Carlson 2005) and seek out examples. For most topics, there are countless syllabi available online (e.g., by searching course names online, and see http://opensyllabusproject.org) from which you can draw inspiration. Your institution might also keep an archive of syllabi. If you have inherited a syllabus, modify it to suit your interests and experience as appropriate and look for ways to incorporate evidence-based teaching and assessment techniques (*section 2.1*). At the same time, getting feedback from experts, including experienced instructors, is useful for identifying scheduling pitfalls, the practicality of learning activities, workload for yourself and students, and more broadly how the course material complements other courses offered by your institution. Getting your students to familiarize themselves with the syllabus can be a challenge; providing a paper copy at the start of the semester, frequently referring to it during the semester, and posting it online will help students retain the important details and help you stay organized and on topic.

2.3. Teach critical thinking

Critical thinking, the ability to independently draw conclusions based on evidence, logic, and intellectual honesty (Rowe et al. 2015, Ennis 2018), is an essential skill for students to develop during their post-secondary education. It is indispensable for answering scientific questions but also for functioning as a responsible and engaged citizen. Students are often drawn to ecology, evolution, and related fields by a desire to understand the natural world. However, introductory courses often focus on foundational concepts without emphasizing the complexity involved in generating scientific knowledge (Alberts 2005, 2009). Ignoring the non-linear paths to knowledge that occur in scientific research risks alienating students from science all together (Rowe et al. 2015) by rewarding memorization over curiosity and logic (Alberts 2009). As such, most aspects of course design including active learning activities, assessment of student performance/learning, and delivery of lectures should incorporate the development of critical thinking as an underlying goal. Hands-on, active learning in field or laboratory settings is one place where critical thinking can naturally be developed. There is a substantial empirical literature on the effectiveness of a variety of teaching techniques for promoting critical thinking development that can be used as examples (e.g., Gardner and Gasper 2013 and references therein).

When in the classroom rather than the field or laboratory, using active learning strategies to develop critical thinking is inherently easier in smaller, upper-level or seminar-style courses, but critical thinking can also be promoted in traditional lecture theatres (useful examples of how to do so are given in Nordlund 2016). A conversational style of lecture can also promote critical thought and engagement more than static monologues designed to prepare students for a trivia-style written examination. In this scenario, knowledge can be presented in an ontological fashion by outlining the history of an idea, significant changes during its development, and criticisms, both historical and contemporary. We believe this critical approach to teaching scientific concepts has four advantages: 1) it is more enjoyable for the instructor because students are likely to be more attentive and engaged; 2) students develop a deeper understanding of the subject matter; 3) presenting conflicting evidence and recapitulating scientific disagreements demonstrates the nature of scientific progress; and 4) students learn that knowledge is not static. Emphasizing scientific controversies not only stokes students' interest, but illustrates that disagreements and arguments drive the advancement of scientific knowledge. In the current "post-truth" era (Iyengar and Massey 2019), it is essential to differentiate between science and pseudoscience, and to understand that revising scientific models does not necessarily render an earlier model 'wrong' or fraudulent.

2.4 Be authentic, approachable, accessible, and transparent

As a first-time instructor, one of the most effective ways of ensuring good relationships between yourself and your students is to convey that you are human and humble. A good starting point for this is to tell your students about yourself (Richmond et al. 2016). This can extend to talking about your weekend activities, hobbies, experiences as an undergraduate, former jobs, personal milestones and setbacks, and mentors. Likewise, to connect with students, it is important to show interest in them as people. For smaller class sizes (<60 students), it is usually possible to learn the students' names through exercises, studying class lists (with photos if possible), and encouraging student participation. Another way to heighten the sense of collegiality in the classroom is to be honest about the uncertainties in our collective knowledge and the limits of your own. Do not be afraid to make it clear that you are learning with your students; this transparent step may also be able to help lessen your sense of imposter syndrome (see *section 1.1*). If you lack a good answer to a question, say so, and return next class with a well-researched answer or assign a student, or the whole class, to do some research and report back.

Accessibility also means being available for in-person conversations, but also being emotionally and mentally prepared to engage. Setting aside time before teaching to go through the plan for class can help you start with a clear mind and be ready to answer questions and interact with students (Kirby et al. 2017). Arriving to class 10–15 minutes early, staying after class for questions, reminding students to schedule a time to meet with you as needed, and responding in a timely manner to e-mails are all good ways to increase your accessibility to students. These actions can help to establish rapport and approachability, and increase classroom participation (Kirby et al. 2017). Finally, it is important to make sure the students know that you have spent a significant amount of time preparing course materials and that you expect a mutually respectful and engaged environment. This strategy can help students see you as a 'real human', respect your time, and maintain a sense of motivation and enthusiasm.

2.5 Be compassionate, inclusive, and empathetic

In all aspects of our academic careers, we can find opportunities to promote equity, diversity, and inclusivity with the goal of ensuring that the upcoming cohort of life scientists and environmental practitioners more closely mirrors society-level demographics. Incorporating inclusive classroom strategies can benefit all students, and especially first-generation attendees who can be at a disadvantage compared to others (Stephens, Townsend, et al. 2012; Stephens, Fryberg et al. 2012). Creating an inclusive and equitable classroom can start with the syllabus (see *section 2.2*), which should be transparent about expectations (ISU 2019a), assessment tools, marking schemes, and how to participate effectively in class, all of which reduce ambiguity over how to succeed in a course (De Vita 2000). To further articulate paths for success, instructors can suggest multiple study strategies, outline how to effectively use office hours, and explain their expectations for communication (e.g., guidelines for in-class discussions) (ISU 2019b). Students live diverse experiences, and on any given day could be facing a variety of serious issues in their personal lives. Responding to the "*help—I'm stressed out*" e-mails in a timely and approachable manner can do a lot to ease students' minds. When possible, give students room to hand in assignments late, write exams at an alternative time or place (ensuring all students are aware of course policies on these issues), or direct them to the appropriate institutional resources; each of these steps can improve the likelihood of success for students dealing with a challenging personal situation. Larger courses will inherently have more students facing personal challenges, so as class size increases it becomes more important to develop a standard and transparent system of handling student issues (note: sometimes these procedures are institutionally mandated and not at the purview of the instructor). For example, have a standard extension listed in your syllabus, and ensure students know what they need to do to be granted an extension. It can be useful to repeatedly remind students of the support services available to them (in e-mails, the syllabus, and lectures), including accessibility services, medical (including mental health) assistance, and other support groups.

More directly related to learning, in-class discussions can be a powerful tool for promoting inclusion. However, in discussions, boundaries should be set to ensure a) there is respect for differing opinions and b) students criticize ideas without criticizing the individual holding them (De Vita 2000, Hockings 2010, UM 2019). Consider including structured opportunities for students to work in groups (e.g., in-class exercises, discussions, debates, term-long group projects), which provide situations in which students learn from one another, identify their strengths and profitable areas for skill-building, and share their personal experiences through the course material (Saunders and Kardia 1997, Hunter et al. 2010). A relatively simple way to encourage inclusivity is to put effort into learning students' pronouns, as well as names (ISU 2019b). While your ability to do so will depend on class size, taking time to address students as unique individuals promotes a sense of belonging. These steps represent a very small cross-section of the many ways to create inclusive post-secondary classrooms (examples of additional resources in the Appendix). Incorporating any of the abovementioned techniques can make students feels more supported, safe, and confident in expressing their views even while they are exposed to a range of ideas and arguments. These simple efforts, in turn, can help to facilitate the academic achievement of all students.

Concluding remarks

Training the next generation of ecologists and evolutionary biologists is an honourable and important task. Teaching is also a challenge for ECRs given that they typically have little experience doing so and face immense pressure to excel in research. Beyond this, there is a need to establish and maintain appropriate work-life balance. For the authors of this editorial, teaching has been simultaneously taxing, rewarding, daunting, and inspiring. We hope that the perspectives shared here can serve as a useful and accessible collection of experience-based advice for ECRs. We recognize that everyone is different and that context matters (e.g., institutional norms, teaching loads, size and type of classes). Therefore, some of the advice provided here may not be directly applicable in all contexts. The most important message that we wish to leave readers with is that you are not alone; there are many other aspiring educators keen to hone their craft and to do so while remaining research-active and leading a balanced life.

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Appendices

Table A1. Some examples of resources available for instructors to develop their teaching techniques or their knowledge about the theory and practice of teaching.

Peer-reviewed journals	Books	Online resources
CBE Life Sciences Education *The American Biology Teacher* *College Teaching* *Review of Educational Research* *Assessment & Evaluation in Higher Education* *Higher Education Research & Development* *Journal of Instructional Pedagogies* *E-learning* *The Journal of Higher Education* *Educational Technology*	*Learning to Teach in Higher Education*, by Ramsden (2002) *Teaching and Learning STEM: A Practical Guide* by Felder and Brent (2016) *Experiential learning: experience as the source of learning and development*, by Kolb (1984) *Theory and Practice of Experiential Education*, by Warren et al. (2008) *Learning and Teaching in Higher Education: The Reflective Professional*, by Light et al. (2009) *Teaching at its Best: A Research-Based Resource for College Instructors*, by Nilson (2010) *Teaching for Quality Learning at University*, by Biggs and Tang (2011)	McGill University Teaching Resources - https://www.mcgill.ca/tls/teaching/resources https://www.mcgill.ca/tpulse/ Carleton University Teaching Resources - https://carleton.ca/edc/teachingresources/ https://serc.carleton.edu/introgeo/index.html The Innovative Instructor Blog - https://ii.library.jhu.edu/ Iowa State University Center for Excellence in Learning and Teaching – http://www.celt.iastate.edu/teaching/ UC Santa Barbara Center for Innovative Teaching, Research and Learning https://www.citral.ucsb.edu/ edX courses – an introduction to evidence-based undergraduate STEM teaching – https://www.edx.org/course/an-introduction-to-evidence-based-undergraduate-stem-teaching and https://www.youtube.com/watch?v=8NIplqaebVM Stanford University Teaching Commons – guidelines for teaching, course development, and student-teacher communication https://teachingcommons.stanford.edu/resources/teaching-resources

Table A2. Examples of non-traditional, creative teaching approaches to consider trying in the classroom (dependent on class size and subject area). Also see Nordlund (2016) for a useful set of examples for ecology courses.

Name	**What it involves**	**References and examples**
Poetry and visual art	Have students develop poetry or visual art in class as a novel way of explaining, exploring, and communicating scientific concepts – evidence suggests creative processes like these can help enhance understanding of and engagement with science and conservation	Januchowski-Hartley et al. (2018) and references therein
Pose "messy problems"	Give students complex scenario-based problems to tackle, with a series of questions designed to structure their approach to problem-solving and assessing solutions.	Dolan and Collins (2015)
Using social media in the classroom	Any tools or social media tie-ins that are purposeful and clear in their intentions can highlight the relevance of a given subject. These tools should not be used as an 'add-on' or a space-filler, but should have a clear teaching purpose.	Soluk and Buddle (2015) McIntyre (2011) Krippel et al. (2010) http://ii.library.jhu.edu/2014/12/10/using-twitter-in-your-course/
Common intellectual experience (CIE)	Creating a CIE is a type of high-impact practice used by instructors to overcome inequalities among students by providing a common basis by which "to teach new concepts and thus build students' [shared] knowledge" (King & McConnell, 2010)	King and McConnell (2010)
Experiential Learning	Experiential Learning (EL) is the application of theory and academic content to real-world experiences; it encourages self-reflection and promotes learning outcomes that are focused on skills used in professional practice. For example, students can be tasked with imagining they are policy-makers responsible for assessing evidence and developing an action plan.	Kolb (1984) Warren et al. (2008) https://serc.carleton.edu/introgeo/interactive/typesoftechniqu.html
Using scientific controversies to engage students	Use controversies/arguments about scientific concepts and their application from the literature to delve into specific topics; discussed in relation to the individual people who did the work and debated one-another. Helps engage students in class and in reading primary articles, emphasizes the value of reproducibility, and the non-linear path to scientific knowledge.	(Brasier 2017)