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BIOGEOGRAPHY COMPENDIUM

Sharing good practices for teaching biogeography

Can you imagine not thinking about distributions of organisms around the world? I have not always done this in the past (Erkens 2013), but it seems logical today. We are not only faced with human migrations but also with, for instance, migrations of human infectious diseases (Murray et al. 2015). In the context of climate change, plants and animals are shifting their ranges, leading to (local) extinctions (Wiens 2016). If humans want to anticipate these shifts in the distribution of biodiversity over earth, we need to understand what drives and has driven this distribution in the past. However, most people are not biogeographers and have not taken college-level biogeography classes (Erkens 2013).

My attention was drawn again to this issue by Cotner et al. (2017). They did a study on the Galápagos Islands investigating tourist guides' knowledge on evolution. In addition, they looked at what the guides teach tourists about evolution. This seems a no-brainer since these islands play such an important role in the history of evolutionary and biogeographical thought (Briggs 2009). However, Cotner et al. (2016) found that the guides have a relatively high acceptance of evolution but actually know little about it. This was explained by the low levels of evolutionary knowledge of Galápagos teachers, which is something they passed on to their students. The authors attribute the guides' lower knowledge level also to the influence of religion on the Galápagos Islands. This interpretation is, however, contradicted by the findings of Mead et al. (2017) who report the absence of a link between understanding and accepting evolution. In a more recent study, Mead et al. (2018) showed that British high school students with a lower science aptitude had a lesser understanding of evolution. They also showed that the quality of science teaching (and thus the quality of the teachers) is important for understanding evolutionary topics (Mead et al. 2017). For evolution (including biogeography) we might thus wonder if we always teach our topics the best way we can.

To teach evolution effectively we need to: [1] use structured active learning, [2] focus on scientific and critical thinking, and [3] directly address misconceptions and student resistance (Nelson 2008). These three elements require a different role and approach from us as teachers (van Merriënboer 2013). We need to make the learning process as student- centered as possible. This means that, at college level for instance, we need to move away from impersonal and passive lectures and recipe-style lab exercises. The effectiveness of elements 2 and 3 are mainly dependent on our own teaching skills. We can train these skills in the surroundings of our own institutes and in interaction with our students. However, element 1 requires something else: high quality learning tasks based on real-life examples (van Merriënboer 2013). Although the complexity of the task may differ according to the student's level (e.g., high school, undergraduate, graduate level, or even more expert), the learning task should be realistic and contain elements of content as well as the tools for problem solving (van Merriënboer 2013). This means that less emphasis should be placed on the solution itself ("answering the questions") and more on training students how to problem solve. In this way, students can learn how to approach a particular type of problem in any setting instead of making it through one particular lab by focusing on the correct answer to one particular question. Unfortunately, building such cases is time consuming and complex for individual instructors. However, as a community we should be able to generate proper cases since together we cover the whole field of biogeography. I am certain that many good labs exist that teach, for instance, island biogeography or ancestral niche reconstruction. The question is: Can I use these labs as well?

A search on Web of Science (17 January 2018) with the key words "education" and "biogeography" yielded only two results if the search field was set to 'Title' and 46 results if the search field was set to 'Topic'. "Biogeography" and "teaching" returned no results when searching only in the 'Title' field (35 in the 'Topic' field). For "evolution" and "education" or "teaching" many more results were found: 723 and 469 respectively. Although not all the results of the last two searches dealt with teaching evolution (the term is also used more generally for change), it is clear that knowledge sharing on how to teach evolution as a whole is much more common. One could argue that biogeography and evolution are not two disparate fields and this comparison does not make sense. However, as I have argued before (Erkens 2013), biogeography is often hidden as a subdiscipline in, for instance, evolutionary biology or systematic biology courses. These results confirm this. In my opinion, biogeography as a discipline is a mature and independent scientific field and should therefore be explicitly mentioned (especially given its societal importance in the context of for instance climate change). This is similar to the avoidance of the word "evolution" in the biomedical field (Antonovics et al. 2007). Many biomedical papers use words as "develop", "acquire", "change", or "emerge" instead of "evolve". This failure to use the words "evolution" and "evolve" by the biomedical community had a direct impact on the public perception of the importance of evolutionary biology for understanding an everyday problem: antibiotic resistance. Likewise, I would argue that the failure to use the word "biogeography" might prevent the public from understanding the importance of this field for contemporary challenges that we as humans need to deal with.

Sharing resources for biogeography education can help to position biogeography as a more independent field and deepen our teaching of its core concepts. Cases that would make inspiring learning tasks are, for instance, the interplay between seasonality, fire and tree cover (Bucini et al. 2017), the impact of mountain building on speciation (Pirie et al. 2017), or using models to investigate what determines species' distributions (Figueiredo et al. 2018). Global change is a key issue in modern understanding of the relationship between humans and nature, and this topic deserves a proper treatment. These and other recent biogeographic researches may not make it into the classroom if they are not communicated in a way that is useful for lecturers and teachers.

As biogeographers, we all use material centered on our own research to teach our students, why not share this in a more accessible way? A good commercial package[1] exists that introduces biogeography as an independent field (developed in close collaboration with scientists) but for more specialised topics this is not the case. Thus, as individual scientists we can make a contribution via publishing a *biogeography compendium* article that provides a short update on a key biogeographical topic (Erkens 2013). We can also go one step further and develop and publish the teaching materials that we use (for which the *biogeography compendium* papers can serve as background reading). Sharing can be online[2] or via more-traditional publications (e.g., Sousa 2016). As to the *biogeography compendium,* such an effort links to two missions of the IBS[3]: increasing both the awareness and interests of the scientific community and the lay public in the contributions of biogeographers, and promoting the training and education of biogeographers so that they may develop sound strategies for studying and conserving the world's biota. I therefore greatly applaud the initiative by Lomolino (2018) in this journal's issue to start a *Biogeography Instructor's Toolkit*. Such an online registry of instructors and courses, and educational resources in biogeography will provide a valuable resource for those who are involved in teaching.

Now why would this help, for instance, the Galápagos Islands teachers? When we provide realistic, contemporary learning tasks, we will increase the chances that these biogeographic topics will be incorporated and taught properly. This will be easier at the university level since lecturers often only need to deal with their own course objectives. Scientists need to collaborate with education professionals to develop high-quality lessons that can become widely used by K-12 teachers as K-12 teachers are more bound by state or national education standards. Nonetheless, K-12 teachers will not delve into scientific literature to make good learning tasks themselves (even though they need to teach the topic). This might be due to time limitations or the fact that scientific papers are not very-accessibly written. Sharing good practices for biogeography teaching therefore benefits us as biogeographers but also contributes to increased knowledge and awareness in the lay public.

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1 https://simbio.com/products-college/Evolution, last accessed 05/04/2018.

2 For example, the Understanding Evolution website shares information on and lesson plans for evolution. One that relates to biogeography is: https://evolution.berkeley.edu/evolibrary/search/lessonsummary.php?&thisaudience=13-16&resource_id=424, last accessed 05/04/2018.

3 https://www.biogeography.org/about-us/mission-statement/, last accessed 05/04/2018.

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