Intro:

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Erin Larson:

Welcome to Making Waves. I'm your cohost, Erin Larson, and you're listening to part three of a four episode mini series on education in freshwater science. In each episode, freshwater scientists will talk about an activity they've used in their class, ranging from activities that take just a few minutes to entire modules of a course. We hope these will help everyone, from high school teachers through college instructors, get new ideas to use in their classes. In this episode I'll be talking with Cayelan Carey, an assistant professor at Virginia Tech, and Kait Farrell, a postdoc at Virginia Tech about modules they've developed to teach students to work with large freshwater datasets and modeling.

Erin Larson:

Welcome to Making Waves, Cayelan and Kait, and thank you for joining us today. To start with, I wanted to talk about what inspired you to create the activity that you'll be describing?

Cayelan Carey:

Sure. I feel like it's really important to start with project EDDIE, which was actually motivated by climate change. EDDIE stands for environmental Data Driven Inquiry Exploration. This was the collaboration that started in 2009 between myself, and Dee Richardson, and Katherine O'Reilly. And we were a bunch of early career scientists. I was actually a grad student at Cornell and Dave was a first semester professor at SUNY New Paltz. And we had to all of a sudden create these labs for freshwater ecology courses. And it was winter and it wasn't actually safe to go out and sample lakes and streams to the ice because it was a really warm winter. And so we decided that we wanted to pull together some really cool data sets that we've been working on for our research and to use them as a basis for teaching freshwater science. And so this also came out of our work in GLEON, the Global Lake Ecological Observatory Network, which was the context in which all of us know each other.

Cayelan Carey:

And so we started developing teaching modules that we were creating for our own classes, but knowing that they were going to be taught in each other's classes, too. And in 2012 we received NSF funding to support scaling up project EDDIE to include 10 different modules. And we also brought in researchers that specifically focused on pedagogy. And the idea behind our modules is that they're flexible, and adaptable, and have the scale of scaffolding activities. We usually refer to these as A, B, and C. So that maybe for your intro level classes, we'll teach A and B as homework, even a more senior class. Maybe there's pre-readings that you would do A and B and then you do C in class. And there's usually homework questions, datasets, and a range of different activities that are geared around different ecological concepts. But we're really excited about using real messy ecological data sets to teach students about different concepts. And the idea is also that we're using these data to help teach them quantitative skills.

Cayelan Carey:

So data analysis, data visualization, looking at variability in real ecosystems. And so that project was funded from 2012, 2013 to 2017. And then I received funding as part of the macro systems grant to have

the next generation of project EDDIE, which is called macro systems EDDIE. In which we are using the same concept of using teaching modules to teach macro systems, ecology concepts. And Kate and I coordinate macro systems EDDIE together and we're still teaching project EDDIE modules and macro system EDDIE. It builds off of project EDDIE in that we're using primarily our based activities instead of Excel in order to thinking a lot about how do we use ecosystem models to teach students about cross scale interactions, interactions and feedbacks that are occurring at a larger scale than perhaps just one or two lakes.

Erin Larson:

Awesome. And so it sounds like you have done this activity across a bunch of different types of classes and institutions, but what's the general class context, where folks have used project EDDIE and macro systems EDDIE?

Kait Farrell:

So I can speak for macro systems EDDIE. Most of our testers so far have been environmental science classes and ecology classes ranging from introductory classes to more specialized fresh water ecology or limnology classes. We design all of these activities with the goal that they can be used by students and instructors who have never used R before. And I think that's a really important part of it, to try to break that mental block about trying something new. So we designed these activities to be about a three to four hour total time commitment with the idea being that they'd be taught in one large lab period for classes that have a lab. Or if it's being taught in a lecture class, they could break it up into multiple days, serve along those ABC activity breaks, or select the subsets that best work for their lecture.

Kait Farrell:

Because we do have a lot of both students and instructors who have never taught in R before, we've developed some also scaffolding materials to help try to bring the students on board and orienting them to R studio and making it as unintimidating as possible for them to get started with it. And then in terms of thinking about the instructors, trying them out for the first time, we often recommend that the instructors give the module a full test run on their own before they try it in the classroom because every computer's a little bit different. And as much as we try to put the modules through lots of different testing scenarios with students, and graduate students, and ourselves, there are all these nuanced computer challenges that they might run into. And it's best if the instructor has a little bit of anticipation of where the bumps along the way might be for their particular students.

Cayelan Carey:

To date, we have taught the project EDDIE modules to somewhere between 10,000 and 15,000 students. And for the macro systems EDDIE modules, we're hopefully going to hit 500 very soon. A really important part of our program is that we very thoroughly assess the modules in which students complete pre and post module questions that we are using to constantly revise the modules and update them. And so, for example, one of the changes that we've been working on is in one of our new macro system EDDIE modules, students develop their own climate, and land use scenarios, and force a Lake ecosystem model to see how the lake responds to potentially different alternate futures. And trying to predict where the likelihood of degraded water quality is greatest in different lakes. And what we found was that for some classes it just takes too much time to complete in a three hour lab period.

Cayelan Carey:

So we just have now pre-made scenarios based off of down-scaled RCP predictions for different lakes. And so we've been trying always to make it as adaptable as possible for different classrooms so that if you only have a two hour lab you could still run our modules. If you have a three to five hour lab, you could have students create their own scenarios.

Erin Larson:

Awesome. And so it sounds like from your description, if you were to briefly describe what the different modules are like, that's a really interesting example of one of them. So they're all working with some big dataset in limnology or some sort of environmental dataset. And then using R to analyze that in some way.

Kait Farrell:

Yeah, so the project EDDIE, the original suite of modules, had a number of different topics where many of them were water focused, but there were also some soil and earthquake type modules happening. The macro systems one, because Cayelan is leading that project, we've decided that we're making them limno focused. And our classrooms have been often aquatic focused, but not always. We find that because of the GLEON datasets, NEON data coming online, USGS gauge data, there's just so much available, high-frequency, messy, real ecology data from aquatic ecosystems that we found would be a really nice ... Also a closed system where we can have students run a whole ecosystem model. For each of the macro systems EDDIE modules so far, we're using the general lake model, which is an open source whole ecosystem simulation model that we set up. And then have the students test different scenarios in. And we've just found so far that the lakes seem to be really a nice system for trying out these ecological data manipulations and scenario building.

Erin Larson:

That's cool. And it's obviously lakes are a nice contained ecosystem in a lot of ways for thinking for students for the first time in some cases about ecosystem modeling and things like that.

Kait Farrell:

Yes, it definitely helps to be able to put a little bit of a bound on ... And we don't provide them with all the caveats about the terrestrial wake interactions. So for the purposes of the modules, but they see them as a unit, which is nice.

Erin Larson:

Yeah. You guys have described a little bit how instructors can prepare to teach these modules. And it sounds like you recommend that people take the time to go through as if they were the student first. Is that what you would say is the preparation time more or less?

Kait Farrell:

Giving it a try yourself in R, especially if you're new with R, is going to make teaching it in front of the students go much more smoothly. As part of the packet of materials that we develop, though, we do create an instructor's manual that has some background information. We have an introductory PowerPoint that the instructors can either use as is or modify to their classroom that has speaker notes and little nuggets of things that they might want to highlight for their students. There's another optional PowerPoint that walks through the introduction to R so they could orient students in R if they need to. And we also provide a student handout worksheet where it has some guiding questions that the

students work through as they're completing the module. Which helps a lot for helping them slow down, make sure that they're reading materials, and not just getting so wrapped up in the excitement of R that they skip the ecology lessons that are embedded within the module.

Cayelan Carey:

I think another part of this is that we really encourage students to work together and teams to complete the modules. And we found that when you have two students working together, that one tends to be in a more dominant position because they're working on their computer. They can run the code much more quickly and you have the partner who's left to the side. But if you have stopped or you have the handout and other ways to stop with embedded discussion questions, that helps keep them both engaged and still allows them to work together to leverage each other's expertise for trying to understand how best to work through the code or the problem set.

Erin Larson:

And so in general, folks are working in teams or in pairs when they're working through this?

Cayelan Carey:

In some of the modules, we have a menu of lakes, where students can pick. And we encourage pairs to be working together, quartets. And so they'll be working through different climate scenarios and different lakes and then seeing how different lakes are responding. So, for example, in the tele connections module, which is a new module that Kate just developed, which is looking at how El Nino is affecting lake dynamics, and water temperature, and water level across the US. You can have the same climate scenarios and the same El Nino years affecting lakes that have different characteristics in really different ways. And so we're looking at where a lake's geographic location will alter how its response to El Nino is during a very extreme El Nino event, for example. And so that's been really fun, too, to have students think about the context of where their lake is located and to be able to compare. And so that helps with the discussion, as well, of why some lakes are responding in different ways than others.

Erin Larson:

Awesome. And so it sounds like you guys have done a lot of thinking about how this activity can be adapted to different types of classes, but have you seen any challenges with having it for a more introductory class versus a more specialized or majors level, more senior class? Do you think it could be taught at a high school level?

Kait Farrell:

Yeah, I think it's certainly possible to teach it at a high school level. You would probably want to break it into maybe more of a subunit, where you're spending a little bit more time building some of the ecological context. And, for example, at a high school environmental science class, but also digging in a little bit more on R, and the structure of R, and why do we want to use things like simulation models. So maybe it's that the three hour module gets blown into a week long unit or subunit on ecosystem modeling. And [inaudible 00:13:06] that way, but I think that the using of the script itself is certainly transferrable to high school students. I know one challenge that we had this past academic year is we had a freshman level class at one of our tests or universities was using the module for the first time. And the students got so bogged down in trying to do some of the installation steps.

Kait Farrell:

They were having a lot of computer problems. And so that's part of what Cayelan mentioned when we're constantly doing the updates, is hearing back from our testing faculty, seeing what bumps they've hit, and if we're able to streamline any of those at all. So I think just a lot of times the senior level or junior level students have just had more experience with hands on labs and maybe with different computing activities. So for introductory level classes, just splitting it out so that you're not rushed and the students have the time that they need to work through those tricky spots I think has been our main findings so far.

Cayelan Carey:

And also things like using computer labs on campus or other resources where we've packaged the modules in different ways to try to make them as most accessible as possible for different levels of students. With the idea being that the ecological concepts should come through whatever combination of activities you'd use, but you might want to use different activities for undergrads versus grads. So, for example, I teach an undergraduate freshwater ecology class and I teach EDDIE modules in both the lecture and the lab, but I've packaged some of the modules that are going into one hour lecture periods in a different way than I do for my three and a half lab periods. And so I feel like there's something where I think a lot of this is knowing what's best for your students and knowing where their level is. And that's something which can be hard for first year professors or first time you're teaching a class.

Cayelan Carey:

And so Kait and I are really committed to helping our instructors that are testing out our modules so that we can help you essentially do whatever you need to do in terms of editing the modules or cutting them so that we can do what's best for your students.

Erin Larson:

Yeah, it's like following a recipe, where you have to make your own tweaks along the way. That's how I always think about teaching in a lot of ways when you get resources from other folks. And so it sounds like you both have done a lot of thinking about updating the different modules. We've covered some of the ideas of things that you've done in the past and how you've changed it moving forward. What are you thinking in the next few years or by the time you're planning to deal with macro systems EDDIE?

Kait Farrell:

Well, we still have have two branding new modules that are on the docket for being built. So that will be sort of our first big next step, is that we have a module. So far modules that are available are about climate change effects on lake temperatures, across scale interactions, and the tele connections module. And our other macro systems topics are for macro scale feedbacks and then sort of a synthesis module. So we'll be building those out in the spring semester and then testing them. And then after that, next steps with macro systems EDDIE, I think it's a really exciting time with the NEON aquatic data really starting to come online. The infrastructure is in place now, but the data isn't quite available in the timeframes, a full year's data to plug into these modules. So I'm excited about making some updates.

Cayelan Carey:

One other thing I'm really excited about is that some of our colleagues in GLEON have started teaching our modules in their universities not in the US. And so thinking a little bit about how we can best adapt these modules, that they're global in scale and not just focused on the US. And so thinking about building in more lakes to model, capturing more gradients so that students can really understand the full

diversity of freshwater ecosystems. And then Kait and I have been talking a lot about different ways of thinking about the next generation of these modules using our markdown, and Jupiter notebooks, and moving into potentially other languages, too. And in addition for thinking about what data analysis skills and what data science skills can we embed in these which can help train the next generation of ecologists.

Erin Larson:

That's awesome. Do students generally like these activities? Are they reacting? I mean, I'm sure they are loving them. I didn't mean to sound skeptical, but what's some of the student feedback you've gotten in terms of things they really enjoy when they do these modules and things that they're either struggling with or maybe they don't like as much?

Kait Farrell:

Yeah, so I think it's funny that you mentioned being skeptical because I think a lot of times, at least for the times that I've helped teach the modules here at Tech, the students are really skeptical. You're asking them to download a new computer program, R and R student, that they've never heard of before, or they've heard of, but in this really worrisome way. R. Then they opened up the program and there's nothing there, right? So they're like, "You've got to be kidding me." We have a lot of skepticism from the students about being able to run the program, being able to figure things out, but I think once they get through that first step of getting their computer set up and they run the baseline model for their lakes, they get so excited because they're like, "Look at this heat map, it's so beautiful." And then they run their climate scenario, their land use scenario, and they start thinking right away about how realistic is this or what if I change that instead?

Kait Farrell:

And so I think that they get really interested in the power of using R and the power of using these whole ecosystem models because it just opens up ideas for them that they never would have been able to access using Excel or the other tools that they've been familiar with so far.

Cayelan Carey:

One of the things that I've really enjoyed is seeing students realize the power of modeling for thinking about future change. And so generally I group the students into two categories. The first is when they have to develop their own climate scenarios for a lake, they will try and get as specific as possible for a lake that's special to them. Maybe a lake where they grew up or spent the summer on as a kid. And they'll really try to look and see how is this lake going to respond in the future.

Cayelan Carey:

The other group are the students that are all for just trying to use the sledgehammer. So what happens if I increased precipitation by a meter a year or what happens if air temperatures go up by 15 degrees C? And so I feel like that's also really valuable, too, for being able to isolate those particular drivers in a way that you just can't in real life. I think the other thing that's emerged from both project EDDIE and macro systems EDDIE is when students are working with real data, they're always struck by how messy it is and how variable it is in terms of thinking about if they're looking at historical data. Maybe they have an annual mean, but actually looking at minute resolution data from a buoy I think blows their mind in terms of I had no idea that thermocline moved up and down or that water temperatures vary that much.

Cayelan Carey:

And the third is, which I think I'm probably the most proud of, is that the data from our assessments continuously show from both project EDDIE and macro systems EDDIE, that what we are doing is helping to build students' confidence in using these tools. And that's the first step in terms of making them proficient in that they feel more confident programming, they feel more confident working with big data in a way that I don't think that they're getting exposed to in other classroom activities. And so I think Kait and I both feel really proud in that we're trying to empower students to get excited and to feel like they're able to do these activities in a way that just simply wouldn't be possible otherwise.

Erin Larson:

Yeah, that's awesome. It sounds like it's teaching them some really important science process skills, too, in terms of thinking about the fact that science is not a lot of very clear cookie cutter answers to questions. Which, in some cases, might be the first time they're experiencing that. And so it sounds like both of you have had a lot of great teaching experience in the aquatic sciences. And so I was wondering for my last question, if you could share any advice that you have for folks who might be teaching in the aquatic sciences for the first time, whether they're grad students or teaching for the first time, a new professor, or anything like that. And I know it's a continuous learning process, but if there's things that you've learned or reflections you have on teaching that you'd like to share.

Cayelan Carey:

For me, I think there's something that's really important about being fearless. And that it's inevitable that you're going to be doing some activity and that it's going to completely bomb, and being okay with that. And I remember the first time I taught one of our primary macro systems EDDIE modules, which is all about introducing students to climate change effects on temperatures. And the first time I taught that, students just looked at me. And they were so overwhelmed, and I was so overwhelmed, and I was a first semester freshwater ecology professor. I honestly feel that if you are excited and enthusiastic about what you're doing, your students will be, too. Maybe it needs to be refined, or the next iteration of that lecture will be more interactive, but there's something about you just need to put yourself out there.

Cayelan Carey:

And I think whenever I'm excited and enthusiastic about any of these modules, students are there with me. They want to be excited. And so I feel like that's 95% of my teaching, is me doing a Daphnia dance or getting really excited about thermocline. And you can do anything if you're excited.

Kait Farrell:

Yeah, I've found, at least with teaching these modules, that it's really important to also show the students that it's okay to be vulnerable, and how much you know, and how comfortable you are with the datasets. So I think that they have gained a lot when there have been times when I screw up something in the demonstration or we run into an error message that we haven't seen before. And they see me panicking, trying to figure out what the error message is, but it's reassuring to them to know that even those of us who they look up to as instructors or are still learning, as well. And that there is no end point to win, you know everything and you're all set. So I think that letting them know that we're all learning together helps them be more comfortable with trying things that they see as hard, too.

Erin Larson:

I think that's all great advice. I want to thank you both for taking time to talk with me today and share some information on project EDDIE and macro system EDDIE. It's been wonderful to have you both on the podcast.

Outro:

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