**Summary - comments from focus groups**

Each focus group (**Table 1**) was asked the same set of questions (**Supplement 3**). Comments extracted from the individual groups as responses to these questions are reported here. In general, the comments are reported as direct quotes, although the statements were lightly edited to remove elements of speech such as “um”, “you know”, etc. Statements in brackets were occasionally included to contextualize the quote. Statements without quotes describe the general tenor of the conversation. Comments are reported by the Focus Group without identifying the specific individual within that group (FG1, FG2, FG3, FG4, or FG5).

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**Questions and Responses**

**What bioinformatics do you teach, if any?**

Intro to bioinformatics (exploring databases and online tools, mentioned Galaxy specifically) and an upper-level bioinformatics course (sequence analysis). For the upper-level class, students do their own projects, including writing the appropriate code.

incorporates bioinformatics into a lot of courses

Online bioinformatics, upper-level and Intro to Genomics and Bioinformatics, has been involved in SEA-Phages

research on flies, involves with GEP and some smaller initiatives

neurobiologist by training, involves some bioinformatics in Genetics and research on *C. elegans*

“Principles of computational biology, which is just using data, science and using programming in biological contexts. (an introductory course).

“I use bioinformatics in the senior research classes.”

“I taught for the second time a more advanced genomics course, where we try to do some more command line stuff in R and some more actual analyses, but that definitely presents some challenges which is sort of what attracted me to this conversation.”

“One of my objectives that has crept up in the last couple of years is troubleshooting, and realizing that it's not mastery of one program, or learning how to use one program, but truly a pipeline where you have to figure out what missing, the tools or steps you need to add. And beyond knowing the applications of each and every tool it's really important to expose students to the thinking and the trouble shooting. Sometimes there are [situations where] you have to think outside the box.”

**Where have you been able to integrate bioinformatics?**

“Usually it involves going from the field into the lab. So the students get wet lab experience related to the field, and usually it's a PCR to sequence something, and then usually we're doing a lot of bar coding or something like that, and I incorporate MEGA to do multiple sequence alignments and to produce phylogenetic trees. And then in an advanced course, I'll get into model testing in MEGA so that they kind of get the quantitative background and the algorithms, and better understand what's going on computationally. Those same things for Gen Bio and I'll, of course, lecture about them. But for lower division students usually it's PCR, BLASTing, getting new sequences, putting them together [in a tree].” *T*his individual mentioned a few specific lessons here and suggested their Gen Bio course was maybe 5% Bioinformatics.

Not integrating much, doing some small things in Gen Bio lab (not lecture), the extent to which is dependent on the specific instructor. More is included for majors than non-majors. This individual then talked about HHMI Biointeractive Lizard Evolution as an intro to sequence divergence as a measure of evolution. They discussed how they incorporated more during COVID when labs weren’t in person, but then went back to wet lab standbys.

Some assignments are included in Gen Bio for majors: modeling, multiple-sequence alignment.

“[We started] a data Analytics Minor, which was kind of my attempt to get some of the bioinformatics type stuff into the courses but that's primarily seen interest from the Business Department and not the Biology Department, which I’m happy about [because] it keeps the minor going but it's been an interesting shift.”

“I like to squeeze in bioinformatics whenever I can. I have some very simple exercises and use them to teach at least the basic principles of bioinformatics. I tried to incorporate them in all of the different classes that have some sort of genetic component to it.”

“I was first attracted to the Genomics Education Partnership because it allowed me to do

some research in my course without all of the tools and technology that I didn't have at the time, (we didn't have pcr machines and gel boxes). So I think that in that way made research more accessible to my students in a lab that didn't have a lot of equipment. The soft skills that my students pick up while annotating genes is invaluable. I tell them all the time you'll probably never annotate a gene again. But you will use copy and paste shortcuts, and learn how to save files in a way that you can find them again, and all that kind of stuff. So I think that soft skills are important. And then the last thing I like is the active learning component that working in bioinformatics allows. I know that I have taught them in lecture that 3 bases are a codon, but when they zoom in in a genome browser and they see it for themselves. They think they have discovered something new, so it's kind of fun to let them explore in a way that isn't costly, and gives them some ownership over it.”

This faculty member is working on trying to get a Biotech track that will incorporate Bioinformatics at their institution. This individual then discussed some of the hurdles that they have encountered in implementing the Biotech track.

**Why is it important to teach students about bioinformatics?**

“There are a lot of job opportunities for students, and many of the students are looking for wet lab work, and they don't realize how many opportunities there are if you know how to analyze data and developing those quantitative skills and data analysis skills.”

“It is imperative that students have an interdisciplinary lens to biological science in any area. So it's not just a skill but it relates to how you connect different areas of study with one another.”

“Expanding their skill sets to think more [about] interdisciplinary.”

“I have had students take my course and then send me an email once they have a position at a job and say, oh, i'm, i'm doing this analysis that [we learned in class].”

“They don't know they need it until they have it. It really helps them get jobs. That's for sure. The other thing is, they don't know what it is until they experience it so they don't know to seek it out as an area of study. But once they have it, I've had many students also ask me. Oh, what can I do with this? And I'm like Well, you can get a Phd in this if you want! So for some of them it piques their interest to not just get a job, but to go on to graduate school in these areas.”

“In 2020, when Covid happened I emphasize that without the tools of bioinformatics we wouldn't have gotten a vaccine so quickly.” Also talked about the fact that sequence databases are open to the public to help motivate students.

“My curiosity spurs their curiosity.” “The intersection of computer science technology with math and biology was a novel experience [for my students in bioinformatics] and so I think, showing that interdisciplinarity of bioinformatics, and how all these different disciplines and fields use it, and takes into the different places is really important, particularly where we are today [in research].

“If you're a working molecular biologist, you can easily spend half your time (even if you're not doing genomics) on the computer, manipulating sequences and so on. So even a very basic level of bioinformatics, of doing a translation and figuring out a reading frame and then doing a multiple sequence alignment and things like that is sort of essential.”

“Make the pitch to the students to take as much math as they can stand, take a coding class, things like that, since mass quantities of data is the direction that all biology is going no matter was [sub-discipline] you’re in.”

“It’s the future.”

“What we consider essential skills for the modern worker.” - in a conversation about how to get students more access to bioinformatics, get them started earlier.

“And so my main thing is trying to expose them [the students] to what they're going to be using out there in the field, as especially with the [rise of]personalized medicine and pharmacogenomics and things like that.”

“If students are going on to graduate school or even medical school, they're [grad and med schools] kind of expecting students to have a little bit of coding and a little bit of understanding of bioinformatics. This is not really part of our curriculum right now.”

“Our students are kind of afraid of it, or just kind of find it really intimidating. But I think it's just a really important skill for them to learn. And then, once they do learn it, I think they really get into the problem-solving aspect of it [and then] they can troubleshoot and solve those problems.” “ My pool of students Isn't super-computer literate. They're very online, but they just find it [bioinformatics/working with computers] daunting or they think oh, that's only for super-nerds. They just don't see themselves as [having the ability to] get those computer skills.”

“And so really to me, is like such an exciting time, because we can form the new generation of biologists where we can actually tell you need both [biology and bioinformatics].”

“It is because of personalized medicine. We need to analyze a lot of data and the tools for that is bioinformatics.”

“We [our small institution] also don't have a lot of resources per se. So some aspects of molecular biology that would make our students more competitive, either in grad school or in the market, is kind of out of our reach, but in some cases bioinformatics tools can be pretty cheap.”

“[It’s important] for students in the classes to have a sense that computers and mathematics are your friends and that if I can do it, anyone can do it basically. it is [also] important to have good computer skills in the job market. I consider it an ethical responsibility for all of us to at least make our students aware of that [and] being gainfully employed is something important.”

“All of our students want to be doctors. They're all going to med school, because that's pretty much what they know but showing them other things, I think, has broadened their horizons.” *and* “I feel more of our students need to be exposed to [bioinformatics] and just showing them applications. And [saying to them] look, this is what real scientists are doing and giving them these skill sets that they can put on their CVs or their resume [for job] applications is helpful.”

“It is something that the students need to be well rounded in biology these days. I believe bioinformatics is a key component of it.”

“Our students, in order to be competitive and out in the world are going to need to have [training in bioinformatics].”

**What barriers do you experience?**

**Student barriers**

*Often heard - students don’t like math/computers or don’t know what bioinformatics is.*

“Many of our students have difficulty or shy away from anything math related or computer related”

“There's some phobia out there around computer science, and so students will come into a biology class, and they're like I didn't sign up to study computers.”

“They [the students] chose biology because it wasn't [perceived as] math, even though it's math is required.”

“The students don't come in with I think much of a sense of interest. [They] just don't even know it exists to some degree, I think.”

“You need to get the students into command-line Unix.”

“I learned command line bash and built github pages. I learned all that coding side of things and have built my class around it. Server [access] is a massive barrier. So I actually ended up learning how and building an app for my class in the CyVerse Discovery Environment and it was free until now, but now they’re charging.”

“Initially there's hesitation about getting into it [SEA-Phages]. But when I show them all the Genbank submissions from past years, they are quite excited that they also want to see their name on [a Genbank submission]. They catch on pretty quickly after the initial hiccups, butI I think students are quite keen on it overall.”

“I think my students come in having no clue what bioinformatics is.”

Got them involved by talking specifically about COVID sequence evolution.

This individual was talking primarily about nursing or chem (not biology) students here: “It’s hard to get buy-in from them or to get them really interested in bioinformatics. At least a few get the exposure.”

This individual mostly teaches nursing students and is trying to convince them of the importance - “It’s the relevancy test that when you present something that you believe is important, it isn’t necessarily important to them.”

“It's a minority of students that can interpret and analyze data when they come to us [a community college]. We specifically have to address those problems for interpreting graphs and tables of data and work with them on that, so they can get those skills up.”

“My students need pushing to apply for things like internships. Or you need to [convince them], “You'd be so great just to apply.” And after, remind them so there is a little bit of self confidence. And then same thing, when approaching something they view as intimidating, like using computer-programming or bioinformatics. They just need that extra push to get them to try.“

It’s hard for students in advanced courses to learn coding and biology at the same time.

“MEGA and all the other things are just too complicated for the level of my students.”

“One of the problems I've had with the Data Analytics Minor, which is kind of my attempt to get some bioinformatics stuff in, is that it's been hard to drag biology students

into it, partially, because there's very low interest. There's also very low knowledge of what it is. It's not something they've heard in high school. It's not something we really are able to integrate into the curriculum with our limited faculty at an introductory level. So if they do see these sorts of tools, they're seeing it in their junior [year], maybe their senior [year], maybe their last semester.”

“They don't want to sit in front of a computer necessarily, even though we try to press on them that even if you're in ecology, that's your job, anyway, for the most part.”

“In the biology program most of the students don't come in with any level of knowledge. it's a lot of building it from the ground up; even before the pandemic.”

“Here [at my institution] the students are variable, but the majority come with very little training, and you have to invest a lot to catch up with knowledge that you suppose [they have], or you expect them to have.”

“I developed a new cell molecular biology lab, and what I try to do is have a [bioinformatics] component for each part of the lab, just to emphasize that that's a tool just like a pipette, a tool. I try to incorporate some form of bioinformatics at the end of each lab just to emphasize that you always have a computer, a tool that's right there along with everything else.”

*Further:* “It didn't work out that well, because [although] I thought they were pretty simple, apparently [they] weren't all that simple [to the students]. And I realized that students these days really have a hard time with things like downloading files to folders and saving them, and knowing where they are going and finding them again. So. So a lot of those sort of really basic skills need to be taught as well.”

“The so-called typical biology student, their skills in anything related to math anything related to numbers is pretty weak. I see that all the way at the graduate level. [There seems to be a] systematic avoidance of math a[nd] statistics. That's why I like to tell them ‘Math is your friend’, which I really believe, ‘if I can do it, you can do it.’”

“I find the students [have poor] attitudes about math often. They'll take my computer-based class and their first thing is, “I hate computers.”

“But if they show up, do the work and have a can-do attitude, they love it. They love this freedom that if they just try and have a good attitude about it, that they'll succeed in the class.

“I think we definitely have the misconception that this is the technology generation, and they all are good at computers.”

This individual went on to say that at their institution they find students don’t have basic computer literacy skills.

“I really focus on the process of using this [the computer] as a tool. You don't really need to know anything. You don't need to be an expert. [You can look things up.]”

This individual brought up in the chat that some students are ready and others are not, and then you have to deal with that challenge - specific quote from chat: “One of the barriers for me is the disparity in readiness of students.”

“[Some are] maybe more interested in it, too. And then the ones who are more motivated, obviously are a lot more successful. They'll work through the barriers of finding stuff. But it does become challenging, trying to keep everyone on the same page and at the same level.”

This individual initiated some discussion about which students jump in and embrace the challenges and which do not, who is willing to struggle with frustration and fail for a while; issues around fear of “breaking” things.

“This might be a community college thing, but my students don't like to read if I give them a big set of directions. They will sit there and raise their hand 10 times to ask the question that's answered in the big set of directions. So getting them over that fear of learning on their own without me telling them [is a hurdle].

*This is sort of in contrast - suggests the savvier students know and push for it.*

“[There is] a lot of interest from around the university, but my classes are over full. And so we're trying to fix that for one. But also it means that I don't really know what my demographics are, yet. It's definitely broader than we're currently reaching, because we're only reaching students who have kind of pushed to get into this classroom.”

“My students who have got that drive to really push their computer skills and have already recognized the economic need. They've found [ ] they can push and get into those classes. But there is a huge proportion of our students who are graduating without ever having taken a formal computer focused course. And so the phrase that I keep bringing up like in meetings with administrators is, do you want our graduates to be able to visualize data in spreadsheets and have installed programs on a computer before.”

“[There are] some essential basic skills that are easily integrated into a more formalized education in my field biology, and how it interacts with computer systems.”

This individual who teaches in a PharmD program: “One of the challenge that we have is that most of the students we receive come from an undergrad [program where] they don't receive so much [training] in bioinformatics,

This individual brought up the lack of bioinformatics positions broadly. “But then there's this massive gap in bioinformatics positions, I think that's very intimidating. Like my university has recently implemented this computational biology track. But if you're a biologist first, and you're not a computer scientist, [then] you don't have simultaneous experience with Ruby and AWS and R and python all in the same person. You have maybe 2 of those. I've heard anecdotally, students [who go out and look for jobs] report that type of experience of difficulties navigating that gap.”

*Often heard - not all students have access to computers/internet*

There was not enough time built into class for students to do the hands-on work at first, so the instructor ended up flipping the class so students watched lectures at home, then came to class to do the hands-on work because some students don’t have a computer at home or an internet connection. There is a computer lab at their school and there are computer loans through school. So worries about “not fair compared to other students.”

Some students are ESL [English as a second language] students as well. “The regular language is a barrier, plus all the technical language.”

Issues around mixed student populations in classes. Usually mostly biology but some CS, chemical or computer or environmental engineering, pharmacy, chemistry.

“Being in basically a rural area (that's why my video is not working). The Internet won't let me do both [have both audio and video running at the same time].”

“Most of my students use their cell phones. I have even the good students writing their term papers on cell phones.” There is some ability to provide laptops to students and there is a computer lab in the library. “It’s a minority that [have laptops] their family has provided.”

“Nothing [software packages for bioinformatics] works on a chromebook and all my students have chromebooks.”

This participant’s school has Chromebooks for loaning to the students, but not all the bioinformatics programs run on them adequately. “We have chromebooks and things we can loan out, but a lot of programs don't function on them.”

*Other issues*

“There are some cultural issues out there, too, for some of our students. Several of our students have had the opportunities to start research, even at the sophomore level, and spend the summer at a state university doing research which is wonderful. but it's easier for our male students to get there. [For] the female students, we've had to do some hand-holding and convincing parents to allow their daughters to leave. There's a limit to what jobs are here locally, and so for many of them, they're going to have to go away, and it's hard for some of the families to let their kids go, especially the daughters of a lot of Hispanic families.” There was more discussion around the idea that students don’t have the economic wherewithal to take off the summer to go work in a lab, even if given funding to travel, etc. They still need to work and pay their bills. Mentioned that they had a grant to do summer work with minority students, but the ones who applied were the upper-class slice, not the ones they hoped to target.

FG3 - One faculty member commented that at their school, there are many non-traditional students, many with full-time work and families.

**Faculty barriers**

*Faculty are often alone in trying to do this at their institution.*

“I'm actually teaching my colleagues how to do this [bioinformatics] at my job, and it wasn't something that was in the job description when they applied but because of [the new skills], then they can expand their horizons and do other things.”

“I just feel a responsibility, because we're surrounded by this approach to solving problems, and so I should be able to demonstrate it within the little confines of my course but it's just not really done here.”

“I just think everything's kind of done the way it's been done for a while.”

“I have colleagues that are definitely interested and maybe dabble. but haven't done as much as I have. Some of what I've done has been for survival and trying to figure out methods I can use to be productive research-wise, while also teaching my students skills.”

“But out of most of the faculty I'm the only one with any real bioinformatics training.” [some discussion here about how one might coordinate with the other faculty teaching Intro courses - it didn’t really seem feasible at this person’s institution ~235 23:30 FG4]

*But glimmers of hope*

“We created a community of 4 or 5 faculty members who are implementing CURE-like experiences that involve bioinformatics tools. [It’s] kind of organic and not super-organized, but certainly we create a little bit of a critical group there that is moving that forward, so that's exciting for me.

*Others mentioned trying to help fellow faculty members with small exercises.*

*Difficulty in staying up to date as the field changes/Need for professional development*

“I would say I would teach a lot more bioinformatics if I were up to date.” “But the problem is that the programs change faster than I could keep up. even though I do research. Trying to keep up with all this is insane. I need a refresher. I feel like I'm doing some really cool cutting edge stuff with my students. But I know I’m behind and so, in order for me to get ahead and find out new things that I can do, and incorporate into both Gen. Bio and advanced courses, I think professional development is going to be key.”

“There's one of me and 50 students with me running around and having the only expertise [in the room] is really hard, so I have to have very clear instructions. It would be great to have a suite of videos students could click on [that explains things like] how do you clean up sequences, or how do you do this exact thing? So now I have to incorporate time to let them explore how to use programs and then let them figure things out, and then they follow, usually step by step, protocols, and if they mess up a step that's what i'm there for. But it would be nice to have more expertise in the classroom to help me to go around and answer questions.”

“We need professional development training. And maybe that should also include staff that come with us for professional development training, because that way there's more hands in the classroom to help.”

“I can’t code.” [and therefore I can’t teach my students this skill.]

“I do not have any coding experience. That's always something at the back of my mind. [My course] is called Introduction to genomics and bioinformatics. So I focus on both aspects. But I really don't go into coding, and I feel kind of a little bit of a fraud there that I don't have that experience of coding.”

“I think one of the barriers is because I’m a molecular biologist, and not a bioinformatician.

My understanding of the coding language [isn’t at that level]. How many analyses I'm running and server size, and how much data? I'm not well versed on it.”

“Those of us that are teaching to teach and educate undergrads having more involvement in the bioinformatics side with the more hardcore data science people, because I know that I get lost in their materials. and I think that there's this barrier of translating from the guys that are at the computer doing it all the time versus what we're trying to do in the classroom. That was a real barrier for me, and has taken years. I was fortunate enough that I got funding and worked with a fantastic bioinformaticist who taught me everything. I credit him. He now left Academia to get paid more someplace else. but he's still so involved with my project and what I'm doing. He introduced me to Data Carpentries.”

“'I’m not trained as a bioinformatician and I couldn't program to save my life. I was trained in the twentieth century pre-genomic era. I learned as I went as these tools became available.”

“I'm not an expert either. I kind of taught myself during my Ph.D. And definitely a biologist and an ecologist by training.”

“But one of the things that I worry about is, am I teaching my students the right topics in bioinformatics? Because I feel like the field has gotten so big, and another issue is that there's not a good textbook out there that I know of for teaching undergraduates bioinformatics.” [mentions there’s one textbook out there that’s 10 years old]. “It’s just hard to know for sure if I’m teaching them the skills that they need.”

“What do we actually teach content-wise? If you go online and you look to see what people are wanting in the job market, it's these data skills. But still I can’t find great research into big specifics in terms of designing my curriculum around specific job market-informed goals. But it's alluding to this economic drive that our students are perceiving that is getting them to sign up for this [bioinformatics] course.”

“But it's difficult, I think, to push the students to [build] that self-confidence, when maybe we don't have it.”

“I'm trying to basically learn it, because my experience is very poor in bioinformatics. I did some when I was doing [research] but I never implemented in the classroom.

“I learned command line bash and built github pages. I learned all that coding side of things and have built my class around it. I actually ended up learning how and building an app for my class in the CyVerse Discovery Environment.”

*Too many things to cover especially in Introductory classes / in the curriculum as a whole*

From a CC instructor - already too much content in both Gen Bio for majors and non-majors courses.

“We’re trying to cater to this broad range [of students with different interests and abilities in math] and nudge up the math phobes to feel more comfortable with quantitative stuff.”

“There are so many things that they have to take already. It’s difficult to shoe-horn in something else even if they probably need it. “

“I think that the challenge is for somebody teaching in a Biology department and

to biology majors is, how do you accomplish 2 things at the same time with the breadth of the content. So at some point you have to sacrifice something for what you perceive [to be] the most efficient or the most effective way of teaching your content while using [bioinformatics] tools.

“At times the very structure of the curriculum, at least in my school, is so traditional that it is really hard to implement activities like bioinformatics.” issues with pre-reqs and prior experience in the curriculum.

“One of the things that I really run into is the tightness of our curriculum. We're fairly small. The biology program has maybe 60 to 100 students in it, and we have 6 total faculty, so if you think about the number of courses in a typical biology rotation each of us [has to] handle. We spread the introductory courses across all [six] of us, and then a few of us pick up our required higher level courses.”

“[It’s hard to] know more or less the standard of what is currently done in bioinformatics; the tools [I used before] probably aren’t used anymore. Basically, I need an update.”

*Need for material for classes/research - sharing out of ideas, but expressing the need for how to find more. Also expressing frustration with how websites change and therefore need to update materials.*

“[The HHMI resources are] designed so nicely that you could implement them and give students a taste, and I think they [the students] want more now at least I hope they do.”

Looks to “web pages that do things for you so I don’t have to maintain some kind of package locally. We don’t really have much in the way of support for anything like that [tech support].”

“[I’m] looking for resources to teach my students better.”

“Where are you going to make room? What are you going to cut? You almost need a curriculum overhaul. If you have it in one class, great, so they do it for one semester, but then there’s nothing to build on. They might lose interest, or forget the skills.”

“The lack of prerequisites that are meaningful for this field [makes it difficult to teach at any but the most basic level]. We don’t have a formal sequence yet, it doesn’t go anywhere, so they just keep learning these introductory materials and never really get to the point where they can implement something fully like a full pipeline from start to finish. That’s what we’re trying to work on right now.”

Further - “I mostly focus on giving a robust foundation in programming via R in R Studio and that’s aided by the fact that we have this cloud-based system that they [the students] can utilize. So as long as they have an internet connection they at least have the opportunity to run somewhat powerful hardware.”

“It's kind of hard to make suitable and easier to understand practicals or exercises. I’m using PDB 101 a lot. For my courses [it] would be nice to have some kind of little laboratory exercises for using bioinformatics tools.”

“It seems like everything every time you get an exercise to give to your students the look of the database has changed yet again. It's very frustrating.”

*Other issues*

**Administrative barriers**

“So we as a department. We're trying to enhance those computational and quantitative skills.” Generally reasonable amounts of support (this institution is developing a Bioinformatics Track - assume within the Biology major), but externals (like the virtual machine idea) don’t currently work well in practice.

“But to learn a new program or the expense of some of the programs I have learned, because I've been doing research with colleagues at other institutions, and I'll learn new programs, but they're very expensive, and that's prohibitive at our college. So we need open access.”

“I remember a few years ago, when I first was hired up at [my institution - a community college], I wanted to implement a PCR lab into the course, and there was resistance to it. Too exotic. I think it's the same thing for my bioinformatics now.”

“Everybody has to do bioinformatics, and to me [part of the issue] is making sure that administration and our colleagues are not scared about bioinformatics, and they are able to also see that to teach it at an entry level does is not going to require so much work from them to learn.”

“We also [need to] have administrators on our side to open classes, right, and not just one class, but maybe a path that right? So the students can take 1, 2, 3 classes. So it's a big problem.”

This individual initiated some discussion about whether bioinformatics should be counted as lab, especially if online - “It’s a different type of lab.” “They’re both important skills.”

*On the other hand*

“So we have various requirements for the major, and one of them is that they have to take an upper level lab, and so I was able to count bioinformatics as a lab class. but that it doesn't really have a separate lab. It's just sort of a studio class. But we're able to convince people that this is the same as doing pipetting and running gels and looking through microscopes. These are tools that you need to do in biology, but I could see where that would be a barrier in some people's minds that this isn't a lab because you're not doing the traditional lab things.”

**Technical barriers**

Acquiring new computers with new operating systems makes it so that some R libraries no longer work, so it’s hard to get students to try things out ahead of time so in-class time is used effectively.

This individual tried to use a virtual machine so all students have access to the same programs, OSs, data sources, but is clunky and slow.

“It’s a lot of work to keep up [to date with changes to external sites, like Ensembl]. “Every year I have to revise all of my code and everything, because as versions update every year it's different. So I have to test everything [ahead of time to make sure it still runs].

[Access to] “servers is a massive barrier. So I actually ended up building an app on the CyVerse Discovery environment and it was free until now, but now they’re charging.” Discussion here about how to pay for things, including server space.

“MEGA software for alignments. It works really well on PCs; it doesn’t work so well on Macs.”

“The Science Department here got a boost with the Covid funds that were put out and aimed at us [institutions like ours]. The problem is, we don't have it in our budget to keep those computers upgraded. When it comes to replacing them, that's gonna be a problem.”

“Of course, when I used to do bioinformatics in the past, I'm a Mac person, and let's say we have Linux people too, and so I used to do bioinformatics with my terminal. But I was kind of losing my mind to try to do it with students in class. [Each student had a] different kind of system. That was a nightmare.”

“We have a lot of Windows machines, and Python doesn't work with Windows. They won't let me install Linux or anything like that and they're very averse to Macs. It's been a hassle trying to get some of the more well-used bioinformatics tools, simply because Python is a really big part of it.”

This person discussed some software packages he attempted to use; computer labs were Windows machines that the IT department had equipped with Linux. Further discussed LatchBio pods and workflows, R Studio, Jupyter notebooks to try to get students to learn how to work with command line a bit, although LatchBio does the coding for you. Efforts didn’t work very well this first time. “That's kind of my current focus: to try to figure out how to solve that problem, to get a really stable cloud-based system that the students can [use], that we all see the same thing [at the same time, and] that they can access from anywhere.” Then went on to mention Google Co-Labs, although that doesn’t work with R, uses python.

**Some other comments**

“So if there were resources out there that I could use, how many people get employed with these skill sets, or something, it would be nice.”

“Yeah, I I tried to look that up from various websites about the projections, right? How many jobs? But there's nothing that I could find specific to bioinformatics. But if it's grouped with, you know, computational analyst or something like that then I can sell that [to the students]. But it's not as closely tied to the biologist.”

This individual talked about how if he was going to use time to develop a research project for students, he wanted to get publications out of it for his effort.

**What can NIBLSE do for you?**

Some people mentioned that it would be great if there were short videos available on common topics - would save classroom time and faculty prep time if could be used “off-the shelf”

Others brought up the idea of badges or other microcredentials that students could use for jobs

**Sharing of useful resources**

“I use DNA Subway and for my students that was a lifesaver. I was able to do bioinformatics during COVID with students at home, using any type of device, either an iPad or a PC or a Mac. It’s free software, so that really changed my approach to bioinformatics. I think that is what I’m going to do from now on.“

Many people are involved in SEA-Phages. Several others are involved in Genomics Education Partnership. Some have used BioLatch, Galaxy, or CoLabs for teaching some coding.