Biologists and Graph Interpretation Network

Why representation matters: Interpreting data to identify factors that affect Black students’ persistence in STEM

A BioGraphI Module Lesson Guide for Instructors

Original Authors
Suann Yang
Department of Biology, SUNY Geneseo

Catherine Quinlan
Department of Curriculum and Instruction, School of Education, Howard University

Course Information
Department/Program: BioGraphI Project
Level: Faculty professional development
Course type: Faculty mentoring network (FMN)
Delivery mode: Online
Students: Faculty or future faculty; adaptable to undergraduate level
Number of students: 8-10
Estimated duration of activity: 30-45 minutes

Expected date or dates of implementation
Fall 2022

Purpose/Background
This activity is designed to introduce the importance of diverse representation of scientists in STEM curricula. It also serves as an example of a BioGraphI module for FMN participants to view prior to the start of their FMN.

List of materials needed for the lesson
- Link to interview on YouTube (total running time, 26:27)
    - https://youtu.be/P_B-Bb40408
- Link to presentation slides
    - 2_PresentationSlides_WhyRepresentationMatters

About BioGraphI modules

This lesson is a BioGraphI module. BioGraphI modules address data literacy while fostering diversity in undergraduate biology classrooms. They are lessons about graph and data interpretation, featuring the scientific contributions of biologists who are members of historically excluded groups (HEGs). They include video interviews with these biologists, allowing students to hear directly from HEGs about their discoveries. For more information about how the BioGraphI project is advancing inclusion in biology and improving data literacy, visit our webpage.

Student Learning Objectives

The BioGraphI Student Learning Outcomes (LOs) describe what students can expect to gain by the end of the BioGraphI lesson. They are written in a format that can be shared directly with students.

Quantitative learning objective(s)

1. (A, Fundamental) Interpret graphs and/or data figures related to the concepts from this lesson
2. Reflect on your perceptions about using graphs or figures in biology.

Diversity/equity/inclusion learning objective(s)

3. Reflect on your perceptions of people who do biology.
4. Compare your own interests and/or identities to those of people who do biology.

Content learning objective(s)

5. Describe the social and cultural factors that affect Black students' persistence in STEM.

Assessments

To help the BioGraphI Project to measure the effectiveness of our modules in improving data literacy and fostering diversity in biology classrooms, we invite your students to participate in a voluntary, anonymous pre-/post-lesson survey (Geneseo IRB #202021048). This survey is designed as an opportunity for reflecting on the Quantitative and D/E/I learning objectives above and administered via LimeSurvey. Click Instructions for access to BioGraphI PrePost-Lesson Student Survey to request a survey to be set up for your students, at least 7 to 10 days in advance of your class meeting date.

Objective(s)	Formative Assessment	Summative Assessments
LO 1, LO 2	BioGraphI Student Pre-Lesson Survey (link for instructions to	BioGraphI Student Post-Lesson Survey (link for instructions to

	access survey) Group discussion of Table 4	access survey)
LO 3, LO 4	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey)	BioGraphI Student Post-Lesson Survey (link for instructions to access survey)
LO 5	Group discussion of Table 4	None

Lesson context

Learning goals of unit

- Create and implement a BioGraphI module about graph and data interpretation that feature the scientific contributions of counterstereotypical biologists who are members of historically excluded groups.

Prerequisite skills or knowledge

- None

Preparation for lesson

- Assign BioGraphI Student Pre-Lesson Survey as homework for students to complete before this in-class activity.
- If you plan to share contact information or assign social media activity as homework, contact the interviewee ahead of time, as a courtesy.

Lesson sequence

Each row of this table is a step of the activity. Column headings reveal what the instructor, interviewee, and students do at each step.

Information from instructor (live in-class)	**Information from scientist (within pre-recorded video interview)**	**Student follow-up or transition activity**
Prior to class, assign any preparation activities	None	Students complete homework/pre-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) ● *Purpose*: prepare for class; LO 2 & 3 – Pre-lesson reflection on data literacy and perceptions of scientists
Provide table without the data a ppt slide	None	**Fundamental activity:** Make reasonable guesses to the patterns of the data, share out ● *Purpose*: Warm-up and icebreaker
Plays first video segment	Explain how to interpret the table we've been working on. (What do the headings mean? How do we interpret the numbers?) ● *Vocabulary to incorporate:* factor selection in exploratory factor analysis (multivariate statistics) Tell me about the research that these data came from: *What were you studying?* ● *Vocabulary to incorporate:* hypothesis, prediction, explanatory (predictor) variables, dependent (response) variables	**Fundamental activity:** Students compare their predictions to the findings. Share out. ● *Purpose*: LO 1A & 2 - Check student understanding of the concepts and vocabulary
Plays next video segment	Tell me about the research that these data came from: *Explain the significance of this research*	*Purpose*: Closes this portion of the lesson

Adds a little info about the scientist (presentation slide)	None	What questions do you have about Dr. Quinlan's path to this work and where she is today? Share out. - *Purpose*: LO 4 - Identifying potential connections between students and scientist
Selects questions that align best to student generated questions; Must show the answers to at least the required interview Qs to students	***Required interview Qs*** **What kinds of research questions interest you the most?** **When and how did you know you wanted to be a scientist?** **Tell us about the paths that led you to your current job.** **What is it like being a scientist who identifies as [fill in the blank]?** **Tell me about a moment when you felt like you really belonged in the field of science.** *Strongly suggested Qs* What is a typical day like for you? *Optional interview Qs* Where did you grow up, and what was it like growing up there?	*Purpose:* Answers the questions identified by students
Plays final video segment Instructor could also provide other resources on Dr. Quinlan (e.g., website, papers, etc.)	Expression of closing sentiments	Students complete homework/post-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) - *Purpose*: LO 2 & 3 – Post-lesson reflection on data literacy and perceptions of scientists Students or instructor could contact Dr. Quinlan to ask remaining questions via email or social media - *Purpose*: LO 4 - Identifying potential connections between students and scientist

Alignment to Universal Design for Learning Guidelines

UDL Guideline	**Alignment in Lesson**
Multiple means of Engagement	Recruiting interest: Students have the opportunity to generate their own questions for the scientist Self-regulation: Students reflect on their dispositions and knowledge of scientists and graph interpretation before and after the lesson
Multiple means of Representation	Perception: Captions are provided on the interview video. Google Slides offers automatic captioning for presenter. Alt text for images provided in Google Slides. Comprehension: Discussion prompts guide information processing for graph interpretation.
Multiple means of Action and Expression	Physical Action: Varied means are used to prompt students (verbal processing via discussion, written reflection following lesson). Expression & Communication: Multiple types of media are used in the lesson (visual, audio, text).

Implementation notes

Notes on our implementation

We anticipate piloting our lesson in Fall 2022. This lesson will be provided as background information to our FMN participants, prior to the first kickoff meeting. Only some of the activities will be used as written. During the first kickoff meeting, participants will share their comparisons of their predictions to the findings in Table 4. The lesson helps motivate participants to create BioGraphI modules that improve the representation of counterstereotypical scientists for their students. Please stay tuned for updated implementation notes after our pilot.

Suggestions for adaptation

For undergraduate courses

Instructors could ask students to respond to the questions in Dr. Quinlan's instrument as pre-lesson homework. For education courses, students could discuss ways in which they can promote persistence of Black students in STEM.

In person delivery

Physical copies of Table 4 could be provided to facilitate discussion. Pairs of participants could discuss their ideas prior to sharing and full group discussion.

References/resources

1. Quinlan, C. L., Picho, K., & Burke, J. (2021). Creating an Instrument to Measure Social and Cultural Self-efficacy Indicators for Persistence of HBCU Undergraduates in STEM. Research in Science Education, 1-19.
2. https://www.visibilityinstem.com/

Funding for BioGraphI

This project is funded by the Directorate for Biological Sciences, Division of Biological Infrastructure as part of efforts to address the challenges posed in Vision and Change in Undergraduate Biology Education: A Call to Action (http://visionandchange/finalreport/). Award number 2120679.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Transcript of interview

0:00-0:38

- Suann Yang (SY): Hi, I'm Dr. Suann Yang, an associate professor at biology at SUNY Geneseo. For this BioGraphI interview, I'm talking today with Dr. Catherine Quinlan, who is an assistant professor in Science Education from the Department of Curriculum and Instruction in the School of Education at Howard University, which is an HBCU. I first learned of Dr. Quinlan's work a few years ago, and Dr. Quinlan is now a key member of the BioGraphI Project Steering Committee. Welcome Dr. Quinlan!

- Catherine Quinlan (CQ): Thank you, Dr. Yang, I appreciate it.

0:38-9:22

- SY: Dr. Quinlan is the first author on a paper called "Creating an instrument to measure social and cultural self-efficacy indicators for persistence of HBCU undergrads in STEM. It's published in Research in Science Education. Today, we're going to chat about this paper. Okay, so Dr. Quinlan, could you start out by telling us about the research that you did in this paper? What were you studying, the purpose of your work, the factors that you were interested in learning more about?
- CQ: Sure! So in this work I was looking at self-efficacy indicators. I wanted to not just look at self-efficacy, actually I wanted to see all the various factors that might impact on students persistence, such as culture, identity, you know and just all the cultural factors that I felt that were easily missed.
- SY: So this was work that hadn't been done before, especially in the context of the students at HBCU?
- CQ: Well, there has been work done on this. I didn't find–I'm trying to remember if any–I don't remember any being done specifically for HBCU. The ones I had read highlighted African Americans, Native Americans, but predominantly at PWIs–predominantly white institutions–or in summer camp programs, and so the other thing was I felt like there were things missing that were specific to being a person of color, being, you know, Black and Black in America that I felt weren't captured.
- SY: All right, thanks, so maybe we could talk about some of your major findings. We can find those in Table 4. Could you pull that up for us and explain how to interpret that table?
- CQ: Sure. So, when we look at the variables, the resulting variables here, it's gone through an entire process of multiple factor analysis here by the statistician. If you notice, the high numbers, let's look at Expectancy for example, those have higher numbers and so the higher numbers that load together tells us that we're measuring the same thing. So whereas I thought, you know, "I see myself in a scientist" becoming assigned, you know, related to Identity or "becoming a scientist is very useful in the future" related to Value and "I look forward to working in a lab" related to Persistence they all seem to be measuring something else and this something else I identified as Expectancy. Expectancy–i'm going back to my paper here–I defined as students motivated thinking about their future, so it's an important factor but this is, you know, this is one of the reasons we do the factor analysis, just to to see which ones which ones load, which ones count, which ones are measuring–are they measuring what they think, what do we think they're measuring, and to what extent are they measuring what we think they're measuring, and if they're not measuring a specific number, if they're not, if, if they load onto, if they're low, then we know that it's not measuring well on that factor that it's loaded onto. If it's negative then we know that those negative number means that actually I did pull up because i'm not a statistician I did pull up and it was interesting to see what the literature said. I'm going to read something here it says a negative loading means the people who earn high on the factor will score low on the variable and when I look at the group here under cognitive

efficacy, it makes sense all of these numbers they're fairly high and but they're negative. Okay so what does that mean? They're high, which means that you know they do they do load onto cognitive self-efficacy, and measures it, but the question is how is it measuring it and what does that really mean. So “I work hard to understand science,” “I have changed how I go about learning in order to understand to do well in science” and “I'm willing to change the way to go about learning in order to do well in science” okay so it's measuring cognitive self-efficacy, but you know the question then becomes what does that mean about your cognitive self-efficacy when you answer this question.

- SY: So it sort of brings up more questions for you now to research in future projects and it's identified some interesting differences in what you expected and how students may be motivated to answer the questions?
- CQ: Absolutely, and this research is not over. I’ve done a second, another round with a larger population in addition to what I did was to do interviews. So the interviews are geared towards understanding, you know, the how and the why. What is, what are these things really saying? Because sometimes when a student answers a question they may be thinking something else, you know, that we don't. Which is one of the reasons I really value qualitative research, because quantitative is important, but it doesn't give us the whole picture.
- SY: Great, yeah. There are a couple more items here that our viewers may be interested in your discussing a little further. So you have a bunch of these labeled with “C,” could you tell us what the “C” stands for and how it relates to these factors that are identified here in the table?
- CQ: Sure, so the “C” stands for Culture and I purposely put those questions in there because I wanted to understand the cultural connections that influence students persistence. Not all of them–it's interesting, all of a cultural connection, if you notice there's not a section on Cultural, because some of these questions diverged out right. Some of them, you know, were specific to family, you know, which I grouped under family self-efficacy. They're really measuring vicarious experiences, right, whether or not the extent to which students–at least, you know, I'm giving you a little hint there, for my some of my interviews, it really influences the extent which they've been able to benefit from vicarious experiences, you know observing and being able to model. So not all of the ones I thought measured was looking at culture, for example, “I am familiar with scientists in my local community,” you know, and so there may be other, and this again relates to science identity, but it could be more complex, right? When we think about a community, and so this is what makes this work very fascinating.
- SY: Yeah, that's for sure! Are there any additional findings from this study that you would like to tell us about, that's outside of this Table 4?
- CQ: Oh my goodness, that's outside of this table? That I didn't make it into this table, for example? Related to, that you mean, related to, um, I think I mentioned all, you know, we started with with some factors, um, no I don't think–so sorry!
- SY: Okay, yeah, no worries, super interesting!

9:23-13:12

- SY:Could you explain the significance of your research kind of big picture-wise? What's the sort of take-home message of this paper?
- CQ: Yes, so well, I think that the take-home message is, even looking at issues of identity affecting students persistence, it's very complex. For example, one of the questions I included, which I mentioned in my paper, I was in conversation with somebody who's been one of the scientists who've been teaching there for over 40 years, and observations made, and I've even you know, as a PI on a grant made the same observations, you know, there are factors that we don't necessarily include or talk about that affects students persistence, such as. you know, financial can they afford to persist? And so it may not even have anything to do with that, and so I wanted to bring in some of these factors, and you know not everyone, it's not intuitive, necessarily to think about that. I mean it's…I think we're getting better at it. I'm seeing more, a couple more studies that have come out looking at some of the, and talking about some of the importance of finances, but the kind of constructs that we create and the type of factors and variables we look at really depends on our own background. It's interesting because we like to see quantitative as, you know, sometimes we think of, oh quantitative is empirical, and positive, you know, positivistic and more sure, and qualitative is not. But what we forget is that we have to think qualitatively in order to reduce those variables down to numbers and so and that's really important I think for anybody looking at data to understand that that there's a person behind the data.
- SY: That ties really nicely into, you know, what our BioGraphI Project is all about: to help learners to find new ways to look at data and think about data, and tie that with the person who did the research to collect the data in these interviews, like this one, telling us about what they found and how it relates to the work they do as a scientist.
- CQ: Absolutely!
- SY: So would you say that the work that we're trying to do in terms of bringing in more counter-stereotypical scientists into classrooms will help to address some of these gaps that may currently exist in curricula, in terms of identities in STEM based on your research?
- CQ: Absolutely, yeah, because if you, it's especially important to bring in scientists of color, Black scientists, as well because we ask different questions. And when it comes to even begin the research and data and when you ask different questions, you'll collect different data, and so I think that's that's really important to remember. The direction of the research will be different depending on our own motivated thinking.
- SY: For sure, thanks for that. I guess that transitions really nicely into the second half of our interview here.

13:12-16:58

- SY: I'd like to ask you a few questions about being a scientist and how you became a scientist. That sound okay?
- CQ: Sure!

- SY: Okay, you had mentioned the sort of big picture type questions that you're interested in studying, you know, your motivations for this research. So, could you give people a flavor of the kinds of research questions that interest you the most?
- CQ: So, it's interesting that you asked me when did I become a scientist, because I think that you know depending on who you're talking to, you know, I may or may not be considered a scientist, right, even though because my research is, it's science education research and I have an expertise in science, i've taken more than enough science, more than the major requirement, but I also use applied cognitive research, and I think more recently in the last couple years I've been including and developing an expertise in using more social and cultural and historical data combined but I'm a qualitative science education researcher. So your question was?
- SY: The kinds of research questions that interest you the most. It sounds like the qualitative research is definitely what captures your interest, although you find a lot of utility in this quantitative research like you have showed us here from Table 4 of your paper.
- CQ: Absolutely, and you know when I started my doctoral program I began following, you know, the quantitative research, I love the quantitative, I mean I you know statistics, you know, was an easy A for me for like, for example, right but I graduated into qualitative because I felt like there were answers I wanted that quantitative just wasn't cutting it for me, so you know, I like to ask, it's a little hard to answer the why questions, and the how questions, you know, using quantitative. You can get a lot of the, right, you can get a lot of the correlation, but how and why and what does that really mean, and so that's why the questions I like to focus on, especially the why and how, especially the plight of Blacks in the United States is, you know, looking to see How do we get here? Why? Especially related to, and and that's really, you know, I mean in some ways frames a lot of the work I do, including my work on, you know, representation, you know, I started off, you know, being funded with the NSF to look at cultural representation and science curriculum and I've changed that to Black representation, so I keep narrowing it down to What does it really mean to me? and for me especially, related to issues of self-efficacy, and what affects that, and other indicators of self-efficacy.
- SY: Thanks for sharing with us those big picture motivations for your work.

17:01-19:30

- SY: What is the typical day like for you? What does that actually mean in practice?
- CQ: I'm going to say there's no typical day. I think every day is atypical and so that's what makes it so typical for me I guess. It's kind of funny because being interdisciplinary in approach could mean one day I'm working on qualitative data, and when I tend, when I work on that am I working it in chunks, because it takes a lot of time, it takes a lot more time to analyze qualitative data than it does for quantitative. It's not just, you're not just popping in numbers and waiting for it to come out, you have to sit down and you're doing line by line, sometimes I mean I remember that from doing my doctoral dissertation doing transcripts. I'm thankful to Zoom now, I wish I had Zoom during my, I mean it probably did

exist, I didn't realize when I was in my doctorate there was Zoom to transcribe for me, but you know, a typical day means that I'm either working on grant related work one day, interviewing if I'm on a trip as I was for this project in the Gullah Geechee Islands. Yeah, it might, or it might be interviewing participants, or it might be involved in focus groups, or it might just be sending out a quantitative questionnaire, or teaching in a lab, not in a lab, but in my case I prepare pre-service teachers in science methods and so, you know, teaching a science methods class.

- SY: So it sounds like a lot of variety from day to day, but a fair bit of focus and dedication, especially going through all that qualitative data.
- CQ: You have to really have your day, you know, organized so that you can have those chunks of time to do that work: my day organized, my mind organized, because it's a lot of switching on and off, for sure.
- SY: For sure! Well, thanks for giving us a snapshot of what it's like to be a science education researcher and educator.

19:30-21:55

- SY: When and how did you know you wanted to do this work? Could you tell us about some of the paths that led you to your current job? That would be helpful.
- CQ: Wow, so when did I know? So after I became a teacher, I went back to grad school after I had my masters. I took a course and the course talked about a history of ideas in science education. And what struck me about some of the books we were reading was, I was reading about, you know, the science education of American girls and I started noticing not only that there was not a book, yeah, history of ideas and science education, it was a history of science education course. It was really interesting, a really, really, good course, but I was looking for, you know, where the black people during this time, right, you know, you're talking about history. I know we existed during that time. Well, it wasn't in a book, so I delved into the historical archives and pulled up some historical archives trying to derive the science from it. And I think this was either 2006 or 2007. But I just I enjoyed the research part of it and so I decided you know i'm going to just pursue the doctorate, but I knew that this would be my focus and this is what's required. You're going to need to develop expertise in curriculum. Expertise, you know, I liked psychology and cognitive psych, so you can figure out how to measure it. You're gonna need to develop, you know, you're gonna need to wear several hats to get to this goal.
- SY: Okay so well it sounded like you kind of fell into the area kind of by accident by taking the class. Once you got excited about it, then you had a very intentional set of decisions where you made your way to your current job.
- CQ: Something like that.
- SY: Yeah it's a combination of luck but also purposefulness.
- CQ: Yeah, purposefulness. Yeah, opportunity, things like that, yeah.

21:55-23:53

- SY: Well, if we go a little further back in time, could you tell us where you grew up and what it was like growing up there, and if it had any it has any impact on your identities as a science education researcher?
- CQ: Absolutely. I, well, I was born in the US I grew up in Guyana and I have a very complex background that have led to multiple identity crises I think, throughout my life. So I think that it certainly aligns with, you know, my interest looking at identity-related things. Looking at self-efficacy indicators for identity. So everything, I think it's interesting as I unpack, you know, my upbringing. It's interesting to see how much it has contributed to, in other words, who I am has contributed to what I research. You know I just, I don't think I always realized that, I think part of the journey was internal.
- SY: Yeah so learning about yourself is helping you to do your work of bringing these identity issues to everyone's attention and how important they are in helping all people, I guess all learners, discover their own science identities and their paths in science.
- CQ: I think that's one way. The other way I think too is learning about all of these has helped me to learn about myself.
- SY: Yeah, so it goes both ways.
- CQ: Yeah, absolutely.
- SY: It’s a continuous journey isn't it?
- CQ: Yes!

23:55-25:48

- SY: Well, I have one last question for you. Could you tell me about a moment when you felt like you really belonged in the field of science for science education research?
- CQ: Wow.I would say now. I think that when I made the plunge to enter into academia, I think I made that decision, probably, I think around 2014, I was listening to a lot of the rhetoric and a lot of things being said and I knew that even if and even though I expected that there would be pushback in my work, but that there was a need for it. My thinking was even if it took 10 years as I built up an expertise it'll still be needed and necessary. So I felt like I belonged mostly because my belonging was not defined by the field, but it was defined by what the field didn't have. And I made the decision that I was going to shape this in the way that I wanted to.
- SY: I think that yeah, for sure your work is really needed and your insights are continuing to help educators open their eyes and see how we should be doing things differently so that we can really have more inclusive and diverse classrooms where everybody does belong.

25:52-26:27

- SY: Well thanks so much for chatting with us today Dr. Quinlan.
- CQ: Thank you, Dr. Yang, I appreciate it.
- SY: And if you want to know more about Dr. Quinlan's work please visit visibilityinstem.com. You can also read “Creating an Instrument to Measure Social and Cultural Self-efficacy Indicators for Persistence of HBCU Undergraduates in STEM.” published in Research in Science Education. We’ve included a link to it below this video.