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About This Issue

By Kim Hales, Editor in Chief
Utah State University

Welcome to the Fall 2020 issue of Utah State University's *Journal on Empowering Teaching Excellence*. Keeping in mind that all of the articles in this issue were in the process of being researched, composed, and submitted well before the COVID-19 pandemic highlights the intuitive and investigative way these authors approach excellence in their field and the timeliness of their efforts to document and share their expertise. This issue offers readers the chance to slow down, take a breath, and explore strategies that enhance the learning experience for students and for instructors under any circumstances and in any content field.

This issue begins with a book review of Gail Rice's 2018 book, *Hitting Pause: 65 Lecture Breaks to Refresh and Reinforce Learning.* Michelle Arnold's (2020) review explains the science-based background and the storytelling style of this book. Arnold states, "Dr. Rice provides ample scholarly evidence that shows pauses facilitate collaboration among students, create a positive and safe environment for learning, and allow students the opportunity to learn how to learn instead of what to learn." This is an informative review of a book that offers essential strategies for slowing down the information super-flow and provides a common thread for the rest of this issue.

Empowering teaching excellence starts at the pre-service phase in Karen D. Hager, Barbara J. Fiechtl, and Summer Gunn's (2020), "Assessing Student Performance Using Video Recordings in Field-Based Experiences." In this age of rapidly changing technology, Hager, et. Al. use video recordings to offer consistent and constructive feedback to undergraduate students engaging in classroom student-teaching experiences. This technique removes some of the complexities of supervisor, classroom teacher, and student schedules and discusses important details surrounding permissions, training, and software download requirements when implementing new technology.

Conversations that promote productive learning environments are the root of excellent teaching practice. In "Enacting Rhetorical Listening: A Process to Support Students' Engagement with Challenging Course Readings" Jessica Rivera-Mueller (2020) offers a discussion on how to create productive learning environments surrounding challenging course

readings. As a social justice educator, Rivera-Mueller acknowledges that "creating productive dialogue can be difficult" and this article explores the rhetorical theory "rhetorical listening" as a way to "creating an understanding of our individual and collective engagement with an author's ideas. In doing so, educators can help students grasp the active—rather than passive—nature of reading."

Slowing down the super-flow of content so that students have an opportunity to engage in assessment and reflection is the pinnacle of excellent teaching. Shawn Miller's (2020) article, "Implementation of a 25-minute Mini-lecture on Learning and Studying in Large-Enrollment First-Year General Chemistry Courses" shows how the slowing down, assessment, reflection process can be implemented in higher education classrooms. Miller states, "instructors can and should assist their students by showing them that approaches to learning and studying can change, and by providing specific guidance on how to change." This article breaks down a lecture on studying and learning into a manageable and essential addition to any course.

Elena Shvidko (2020) offers insight on instructor response as a way to enhance the feedback experience for both students and instructors. Her article, "Taking into Account Interpersonal Aspects of Teacher Feedback: Principles of Responding to Student Writing" explores the dynamic regarding instructor feedback at the most basic, human level. Shvidko's article offers insight and instruction on the importance of thoughtful, constructive, and collaborative feedback to student's writing. She explains the difference between appropriation and intervention and gives specific examples to help instructors identify and improve their feedback style.

One other way to improve feedback style is explored in "Effects of Three Classroom Research Experiences on Science Attitudes". Lauren K. Lucas, Frances K. Hunter, and Zachariah Gompert (2020) explain how changes in the lab experiences for a beginning biology course created more authentic scientific inquiry opportunities and impacted science attitudes. While not all of the results were as expected, the article takes a close look at how to use feedback to continually improve teaching methods for an enhanced student and instructor learning experience. By being thoughtful in ways to improve teaching methods, Lucas, et. Al. share yet another way that the 'quality over quantity' approach impacts learning at all levels.

Whether it be videotaping, guided classroom conversations, lecture-based, or written, feedback is the backbone of educational excellence. We use it to mentor beginning undergraduates, writers, readers, explorers, and experimenters. And, if we are thoughtful, feedback becomes a loop by which we slow down learning, we engage reading, writing and exploring, and we collaborate our way to becoming better.

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Giving Students a Chance to Learn: Hitting Pause and Engaging Students

Reviewer: Michelle Arnold
Utah State University

Book Review:

Rice, G. T. (2018). Hitting pause: 65 lecture breaks to refresh and reinforce learning. Sterling, VA: Stylus Publishing, LLC.

ProQuest Ebook Central, https://ebookcentral-proquest-com.dist.lib.usu.edu/lib/USU/detail.action?docID=5210875.

> "We know it is not what we teach that counts, it's what our learners learn. It's not enough to merely spout information. If our students don't learn, we haven't taught, no matter how much information we provide" (Rice, 2018, p. 12).

During the upheaval of higher education in the spring of 2020, it became glaringly apparent that as instructors, we needed to adapt to our new circumstances, or our student's education would suffer. The confusion and upheaval that occurred due to Covid-19 and, in turn, the many restrictions on "traditional" teaching techniques have forced instructors across the nation to reexamine their methods and become more attentive to student learning. For many of us, fear and doubt crept in when reviewing our teaching abilities in this new environment, but from that, a new era has dawned on higher education. A transition for most of us resting on our laurels, to diving back into the literature and taking our teaching to a whole new level. Dr. Gail Rice's book, *Hitting Pause, 65 Lecture Breaks to Refresh and Reinforce Learning,* is one of those books that an instructor can use to implement immediate and intentional changes in their "classroom" to renew student learning during these difficult times.

Dr. Rice urges instructors not to completely do away with lectures but instead to revamp their current style of teaching to include *lecture pauses*. "A lecture pause occurs when instructor talk stops, and students are asked to think about their learning and what they will do with it" (Rice, pg. 14). She argues that these lecture pauses not only benefit the students by allowing them a chance to relate and recall, but it also benefits the instructors. When the students have

a chance to pause during a lecture, it gives the instructor an opportunity to assess what the students know, what they are getting out of the class, and how they can be more effective in their instruction. While *Hitting Pause* definitely has a storytelling feel to it, filled with relatable anecdotes, Part 2 of the book is dedicated to addressing the brain science evidence-based pedagogy supporting lecture pauses.

Lecture pauses have been shown to improve not only retention among students but teach important skills necessary to learning. Dr. Rice provides ample scholarly evidence that shows pauses facilitate collaboration among students, create a positive and safe environment for learning, and allow students the opportunity to learn how to learn instead of what to learn. In the classroom, both in a traditional classroom and online, instructors are obligated to build a community of learning and lecture pauses give the instructor that opportunity. When students are given the opportunity to direct their own learning on a topic, make connections, and evaluate ideas in a safe and welcoming environment with their peers, their opportunities to succeed in the classroom and in the life increase. "Learning how to learn may be the most valuable skill we help students develop" (Rice, pg. 29), and Dr. Rice suggests three forms of pauses that can help achieve that skill.

Three categories of lecture pauses are presented in *Hitting Pause* - starting pauses, midpauses, and closing pauses – all of which have their own primary objectives for student learning. Starting pauses "grab attention, focus, and break preoccupation" (Rice, pg. 40). These pauses give the class a chance to come together and prepare for the information coming their way. With all the stresses and calls for our attention during these challenging times, getting a student's attention in class or online can be difficult. Beginning the class with a pause allows students to become engaged and directed towards class. While a starting pause is meant to get the student's attention, a midpause is meant to keep it. A well placed midpause allows the students to remember, apply, and understand what they have learned. This also benefits the teacher by allowing them to redirect their own energies for a time and recognize where the students are in understanding the presented material. Midpauses also help prevent students from experience cognitive overload. Finally, closing pauses are designed as a powerful learning tool because "of the tasks they help students accomplish but also because of when they occur" (Rice, pg. 59). These pauses stick in the minds of the students due to the recency effect; they remember what happened last. Therefore, instructors can make the most significant impact on their closing pauses by focusing the attention of students on major takeaways, finalizing the lesson, summoning a call to action, and referencing the students' own lives.

Lectures allow instructors control over the classroom, what is being said, and how it is conveyed. Pauses put the learning back to the students, while facilitating the learning becomes the goal of the instructor. Pauses can be uncomfortable and frightening for both the instructor

and students because each must reimagine what the classroom experience can be utilized for and what skills they need to develop to succeed in it. What is so exciting about Dr. Rice's book is that it gives 65 pauses an instructor can adapt and use in their classroom. The appendix, which is longer than the main part of the book, gives 65 pauses divided among starting, mid-, and closing, which can be utilized within a wide range of classroom settings and for a variety of reasons. Each pause suggests when it should be used (starting, mid-, closing), what type of setting it would work best in (online, lab, small classes, etc..), the characteristics of the pause (focus, review, bookend, affirming etc.), how to implement them, additional suggestions, AND online adaptions. These pauses might make us think about our instruction differently, but isn't that part of our jobs as educators? When we stop growing in our instruction, we stop thinking "how can I do this better for my students" and start thinking "my way is the right way."

Overall, Dr. Rice's book, *Hitting Pause, 65 Lecture Breaks to Refresh and Reinforce,* is a tool that no instructor should be without. No matter if you are just starting off teaching or have been teaching for decades, this book gives insight, through evidence-based research, on how intentional pauses can improve instruction and student retention. Pauses can be used in the traditional classroom to help students focus, understand what they have been taught, apply it to their own lives, and have an overall more enjoyable learning experience. What is amazing about pauses is that they can accomplish these same things in the online/broadcast learning environment. Instead of just posting a lecture online and having a student do an assignment after, instructors can break the assignment into pauses. This would be a starting pause asking what they know about the topic, a midpause for them to reach out to a fellow student to share something they learned from the lecture, and a closing pause having them apply what they learned to a real-life issue or problem.

How we teach impacts our students, especially in times of chaos and uncertainty. As instructors, we can continue to act as if this is just business as usual, keeping to the same old lectures and the same ways of instruction. Pausing to just take a breath feels like a luxury somedays; how can we find time to restructure lectures and still cover all the information we must teach. However, the book *Hitting Pause* challenges us to be better and adapt to the new age of teaching we all find ourselves in. It not only presents the evidence that pauses help students' focus, retention, metacognition, and the classroom environment, but directions on how to utilize them in already established lectures. As instructors, if all we have to do is stop talking and pause to improve the learning experience for our students, why wouldn't we?

Assessing Student Performance Using Video Recordings in Field-Based Experiences

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Abstract

Field-based experiences are vital components of many undergraduate programs. However, assessing student performance in these settings can be challenging. Video-based observation is an approach to providing performance feedback that addresses these challenges and may also provide benefits not inherent in live observations. Using examples from our teacher preparation programs, we (a) explain the benefits and challenges of using video recordings in field-based experiences; (b) identify the video recording platform we use; (c) describe specific examples in our program, including supervisor performance feedback to preservice teachers, peer feedback/coaching, and instructor feedback on in-home family coaching; and (d) address the logistics of using video recording, including training and getting permissions.

Keywords: Assessment, Field-Based Experiences, Video Recording

Many undergraduate programs include field-based experiences. These experiences provide opportunities for students to apply the knowledge and skills they acquire in university-based courses to real life settings, so they are a vital component to the overall program. However, assessing student performance in these experiences can be difficult. Challenges of conducting live observations include reactivity, scheduling, and cost. Reactivity refers to the fact that the presence of an observer may influence the behavior of those being observed (Cooper, Heron, & Heward, 2007). Scheduling is difficult because live observations require the supervisor to be in a specific place at a specific time, and if the student to be observed is at a distance from the campus, the cost of mileage to send supervisors to the site can be significant (Hager, Baird, & Spriggs, 2012; Schmidt, Gage, Gage, Cox, & McLeskey, 2015). To address these issues in our teacher preparation programs, we incorporated video-based observations. The strategies we use may be applicable to other programs that require field-based experiences.

Students in our teacher preparation programs have a field-based experience each semester. These placements are often in schools, but may also be in family homes for those preparing to work with infants and toddlers. We assess student performance in these settings based on video recordings submitted by the students because, in addition to addressing the challenges noted above, video-based feedback has some benefits not inherent in feedback based on live observations (Dymond, Renzaglia, Halle, Chadsey, & Bentz, 2008). In the sections below we will (a) explain the benefits and challenges of using video recordings in field-based experiences; (b) identify the video recording platform we use; (c) describe specific examples in our program, including supervisor performance feedback to preservice teachers, peer feedback/coaching, and instructor feedback on in-home family coaching; and (d) address the logistics of using video recording, including training and getting permissions.

Benefits and Challenges of Video Recording

Video recording field-based performances has benefits and challenges for both the instructor and the students. It can save significant time for the instructor, as it eliminates the need to drive to a specific site at a specific time to conduct a field-based observation. The flexibility of being able to watch the video outside of typical school hours allows supervisors to observe more students and enables current teachers to serve as supervisors because they do not need to be available during school hours. Video-based feedback also supports more accurate data collection because the performance can be viewed more than once, if necessary. Benefits for students include decreasing the stress they often feel when being observed live and eliminating the need to arrange observations around the supervisor's schedule. An additional benefit, and one that is critical for our students, is the opportunity to view their own performance, described by Knight (2014) as a "game changer" in improving performance. The examples below describe how our students evaluate their own performance, as well as that of their peers. Managing the technology is the biggest challenge for both instructors and students, and we discuss this in the logistics section below. The delay in feedback, as compared to a live observation, can also be a challenge to both instructors and students. We address this by requiring students to receive feedback within 48 hours of submitting the recording.

Video Recording Platform

We use GoReact (https://get.goreact.com/), a platform that supports online video feedback. Before reviewing video recording companies, we identified the features we required, including security (FERPA and HIPPA), time-stamped feedback capability, integrated data collection, a user-friendly interface, and Learning Management System integration. GoReact

includes all these features; how we use them in our program will be described in the program examples below.

Examples of Video Recording-Based Assessments

Performance Feedback to Preservice Teachers.

Students in our teacher preparation program are placed in elementary and middle/high schools each semester to provide academic and behavioral instruction to students in special education classrooms. In order to provide feedback on their performance, they are observed by a university supervisor several times each semester. Video recording is the main strategy for observing these students.

An online training module is provided to the supervisors and the students to prepare them for video recorded observations. It includes instructions for downloading the GoReact app, creating and uploading a test video, and general instructions for video recorded observations (e.g., schedule of observations, data collection forms). The university supervisor then identifies a specific time and lesson to record (e.g., 9:30am reading group on Wednesday). The supervisor also schedules a time to review the lesson together (e.g., 4pm on Thursday). The student then records the identified lesson, and uploads it to the course assignment page (created by the supervisor). The supervisor then watches the recording and types in comments to provide feedback. The video automatically stops when typing begins and resumes playing once the comment is finished (i.e., the supervisor hits "enter"). The comment is linked to that specific point in the video. Clicking on the comment cues up that point in the video, and clicking on the marker in the video that indicates a comment will bring up that comment. This feature makes it easy for the student to view the exact moment in the lesson that the supervisor is referring to in the comment. This is critical for skill development as the student sees exactly what he/she was doing that was effective ("Great error correction – you did the model, skipped the lead because this student does not need it, and did both a test and a delayed test – perfect!") or that needs to be revised ("When the student remembers to bring all her materials to the group, reinforce her with a high-5 or a Panther Paw"). The supervisor and student then meet, usually online, to further discuss the observation.

The video recordings are also used for student self-evaluations. It is important for them to learn to evaluate their own performance. We provide a simplified version of the evaluation forms the supervisors use and the students view their recordings to collect data on their own performance and create goals for skills they want to improve. A useful feature of GoReact is that the supervisor can provide feedback on the lesson, but then choose not to reveal it to the

student until the student has uploaded his/her own comments. Another helpful feature of GoReact is the availability of markers to use while reviewing a recording. The reviewer labels different colored markers with the relevant behaviors, and then each time the behavior occurs, clicking the marker will mark the occurrence in the recording. In teacher preparation, behaviors we mark include providing verbal praise, opportunities for the pupils to respond, and using an error correction procedure, but any behavior that is observable can be noted with the markers. This system can also generate graphs of the markers, to display how many times the behavior occurred, as well as when the behavior occurred.

Peer Feedback/Coaching.

Inclusive programs for preschoolers with disabilities, i.e., those that include children with and without disabilities, are increasing in many states. A common model to provide adequate support in community preschools for those students with disabilities entails the special education teacher consulting with and coaching an early childhood educator to provide appropriate instruction for a child and to use effective strategies with fidelity (Buysse, 2004; Dinnebeil, 2014). In order for these programs to provide the most effective instruction for young children, the special education teacher needs to develop skills in consulting or coaching another teacher/adult. A deep understanding, as well as practice using these coaching skills, should be, but often is not, included in the preservice program (Dinnebeil, 2014).

In our preservice program for preschool special educators, we have an additional challenge of providing a peer coaching experience to students participating in an alternative certification program that is delivered in an online synchronous format to students across the state. Thus, the students are not geographically close to each other or the instructor, yet need to practice coaching each other by observing instruction and then meeting to share feedback. They not only need to learn to give positive and constructive feedback, they must learn to do so virtually, based on video recordings.

We created an assignment that first requires the students to choose a classroom strategy they want to improve. To assist them in analyzing their current practice, they complete a checklist on their classroom skills, as well as their use of coaching skills. Once the students chose a practice (e.g., environmental arrangements, embedding additional learning opportunities, systematic training for staff, data collection procedures), they are paired with a classmate. The coaching literature stresses building a relationship between coach and coachee in all formats (Buysse & Wesley, 2004). In order to create an opportunity to build a relationship virtually, multiple meetings were incorporated into the assignment. Each teacher is required to view three video recorded lessons of the partner's classroom instruction, and then conduct three synchronous feedback sessions, which are also video recorded. Each cycle of these

meetings is completed within a three-week span; with feedback sessions occurring within four days of uploading the recording. This schedule ensures each teacher has time (e.g., two weeks) to practice the recommendations before the next observation. GoReact allows the course instructor to control access to the uploaded video recordings, so the partners are provided access to view and comment on each other's recordings.

Since the instructors have access to all recordings submitted, they can also view them and provide suggestions to the coaches on ways to strengthen their observation skills, as well as view the video recorded feedback sessions and provide input to both teachers regarding coaching communication skills. The assignment rubric guides students during the feedback sessions to help improve their delivery of coaching concepts covered in the course readings and lectures.

Feedback from students shows that the goals of the assignment are being met. Students comment about the fact that they are much more comfortable giving feedback, especially constructive feedback because of practicing with each other. Several comments also suggest that this experience helps build community among the students in that they feel more connected to other preschool teachers and plan to stay in contact once their course work is complete, due to building a relationship virtually.

Performance Feedback on Coaching Families.

In addition to coaching other teachers, students in our early childhood special education program must develop competency coaching families. To evaluate these skills, they submit a video recording of a home visit.

Students video record their home visit/parent coaching sessions and upload these recordings for instructor feedback. The process is similar to that described above in the section on performance feedback to preservice teachers. Students are instructed to review the feedback, respond to any questions posed by the supervisor, and ask for clarification as needed. If a student does not meet the minimal score for this assessment, the supervisor schedules a meeting with the student to review the video and feedback together. When they view a part of the recording that demonstrates an error on the student's part, they pause it and then role play the appropriate actions until the student demonstrates the appropriate response. The student is then required to submit a new video recording for evaluation to demonstrate mastery at the level required for the assignment. Particularly due to the context of providing coaching in the home environment, this approach is less intrusive for families than a live supervisor observation.

Logistics of Using Video-Based Assessment

Using video recordings to assess student performance in field -based experiences has proven to be efficient and effective, but successful implementation requires systematic planning by the instructor. We have found the following to be critical to effective use of video recordings in our program: training in use of the technology for instructors, supervisors, and students; instruction on confidentiality of video recordings, and getting consent for video recording. To address the technology issue, it is critical to ensure both faculty and students receive adequate training. We developed an online module demonstrating use of the technology, created documents with step-by-step instructions (e.g., camera orientation, lighting, ensuring batteries are charged), and required students to create a test video before actually video recording for an assignment. We also developed specific protocols for each type of assignment with timelines for each step.

In environments in which consent for video recording is required, faculty obtain this consent and/or provide consent documents for the student to have signed by the appropriate individuals. Our students are often recording in schools, so we obtain consent at the district level, and if requested, at the classroom and family levels. Because the video recordings capture children in the schools, we also require students entering our program to sign an agreement to treat video recordings created for coursework as confidential material and to delete all videos from recording devices upon upload to the instructor.

Conclusion

Some of the most beneficial experiences in undergraduate programs, including field-based placements, take place outside the university classroom. In order to ensure students are able to apply the knowledge and skills acquired in their university-based courses when they are in the field, it is necessary to provide effective performance feedback. Incorporating technology, such as time-stamped video feedback, can provide an effective strategy that eliminates some of the challenges of live observation and feedback, while adding benefits inherent in using video recordings for assessing performance in field placements.

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Enacting Rhetorical Listening: A Process to Support Students' Engagement with Challenging Course Readings

Jessica Rivera-Mueller, Ph.D.
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Abstract

Many educators assign course readings to purposefully enlarge students' perspectives. In doing so, though, educators may face a range of behaviors—reluctance, resistance, avoidance, disengagement—from students who feel that such readings negatively press upon their prior knowledge, belief systems, or educational goals. This teaching challenge is often present for social justice educators. However, "rhetorical listening," a rhetorical theory developed by Ratcliffe (2005), is a pedagogical tool that can help shift students' understandings of and expectations for the activity of reading, thereby creating a learning environment that supports meaningful engagement with challenging course readings. In this article, the author outlines a process for enacting rhetorical listening and describes the pedagogical outcomes that have been achieved through this process.

Keywords: literacy development, social justice teaching, student engagement, teacher education

Many educators assign course readings to purposefully enlarge students' perspectives. In doing so, though, educators may face a range of behaviors—reluctance, resistance, avoidance, disengagement—from students who feel that such readings negatively press upon their prior knowledge, belief systems, or educational goals. This can be the case particularly for social justice educators, teachers who push students to confront the ethical consequences of their actions and beliefs. As an English teacher educator, for example, I push students to examine the ethical dimensions of teaching standard written English. When my students become secondary or college-level English teachers, it is likely that they will be asked or required to teach standard written English. As a social justice educator, I believe that it is imperative for

my students to grapple with the arguments that surround this expectation to create ethical pedagogical practices. As a result, I assign readings such as Baker-Bell's (2017) book chapter, "'I Can Switch My Language, But I Can't Switch My Skin': What Teachers Must Understand About Linguistic Racism." With this reading and others like it, I want my students to grapple with hard ideas (such as systemic racism) that are related to their future work. In these conversations, I do not want students to tell me what they think I want to hear or avoid the reading. Like many social justice educators, I hope these conversations open dialogue among multiple perspectives and foster critical thinking on these topics.

However, as many social justice educators know, creating productive dialogue can be difficult. As Applebaum (2009) explains, "social justice education [can be] accused of being ideological and counter to education" (p. 382). When students believe that education can somehow be "neutral" or free from ideology, they often view challenging course reading as a process that must be endured, rather than engaged. While some students may never be convinced that education is, in fact, always ideological, "rhetorical listening," a rhetorical theory developed by Ratcliffe (2005), helps me engage this tension and create a more productive learning environment. In this article, I share a process for enacting rhetorical listening. This process, I argue, is a pedagogical tool for helping students engage with ideas that they may find ideologically challenging.

Rhetorical Listening and Reading

The distinction between hearing someone and listening to someone is commonplace. Many people have had the experience of saying, "You may be hearing me, but you are not listening to me." Listening is a common way people convey the moments when they feel understood or when someone attempts to understand their perspective. It is this distinction between hearing and listening that Ratcliffe (2005) builds upon in her theory of rhetorical listening. Ratcliffe (2005) defines rhetorical listening as "a stance of openness that a person may choose to assume in relation to any person, text, or culture" (p. 1). For Ratcliffe (2005), choosing to be open to a text means we actively attempt to understand ourselves and others. We identify the places where our commonalities and differences shape our responses to texts and analyze how cultures shape these responses. In this pursuit, we proceed with what Ratcliffe (2005) terms as "an accountability logic," which is the recognition that we have a stake in each other's lives. The ultimate purpose of rhetorical listening is to "promote productive communication, especially but not solely cross-culturally" (Ratcliffe, 2005, p. 25). Accordingly, the theory encourages us to actively listen in a way that promotes understanding and further dialogue.

The practice of rhetorical listening emphasizes how our engagement with and responses to texts are always constructed—by our identities, lived experience, prior knowledge, beliefs, and values—rather than inevitable or fixed. When we conceptualize our engagement with texts as something we make, rather than something that happens to us, we are positioned to study and learn from that process. We can, in fact, gain a better understanding of self and others. When we apply this process to the activity of reading, we are able to identify and examine the ways readers create meaning from texts. Additionally, we are able to learn from the ways readers construct similar and/or different meanings from readings.

Asking students to rhetorically listen to a challenging course reading creates a new purpose for the activity of reading. It shifts the focus from receiving an author's ideas to creating an understanding of our individual and collective engagement with an author's ideas. In doing so, educators can help students grasp the active—rather than passive—nature of reading. To clarify this process of creating an understanding, Ratcliffe (2005) provides the following explanation:

> [R]hetorical listeners might best invert the term understanding and define it as standing under, that is, consciously standing under discourses that surround us and others while consciously acknowledging all our particular—and very fluid—standpoints. Standing under discourses means letting discourses wash over, through, and around us and then letting them lie there to inform our politics and ethics. (p. 28)

When listening rhetorically, we slow down our response to a reading, actively paying attention to how language is washing over, through, and around us.

The process that I have designed to enact rhetorical listening involves two parts: an opportunity for students to rhetorically listen to a reading individually and an opportunity for students to share and discuss these experiences in small and/or whole-class discussions. Prompting students to actively construct a reading of a text, analyze that construction individually, and discuss those constructions collectively allows learners to engage with the ideas raised in the readings and with each other's perspectives. Both the individual reading and the discussion experiences are framed by three questions, which are described below. The questions that I offer —ones inspired by Ratcliffe's (2005) theory—are ones that I use to shift students' expectations for reading and promote dialogue about the ideas raised in the readings. Because the goal of rhetorical listening is a better understanding of self and others, these questions make those possibilities visible, which is necessary for critical thinking and engagement.

Questions to Facilitate Rhetorical Listening

To introduce rhetorical listening to students, I explain that rhetorical listening is reading for a new purpose—to gain a deeper understanding of ourselves and others. According to Ratcliffe (2005), rhetorical listening focuses on "listening with intent," rather than for intent of an author (p. 46). Accordingly, this process focuses primarily on how varying readers construct meaning from a text. The course reading, then, is a vehicle for gaining a deeper understanding of how we relate to the ideas raised in the reading and how our understandings are similar and different from others. In this way, rhetorical listening helps us pay attention to our reading processes and facilitate class discussion. To prepare students for this practice, I first describe closed—as opposed to open—stances toward reading. For example, rhetorical listening is not reading to find ideas that support our own, reading to identify the places where we agree or disagree, nor reading to prove that an argument, idea, or perspective is wrong. During this explanation, I emphasize that these other purposes for reading are not wrong. In fact, they are necessary and important in particular contexts. I aim to make clear, though, that these purposes for reading are not associated with rhetorical listening.

After defining rhetorical listening, I introduce the three questions that are described below. Together, the questions enact different facets of rhetorical listening, and we use these questions individually and collectively. First, I ask students to reflect upon these questions when reading independently outside of class. This process allows students to examine how they are actively constructing meaning from the text. Then, I frame our class discussion about our reading experiences around these questions. Sharing our individual rhetorical listening experiences in small or whole-class discussions allows students to learn from each other's experiences. It also challenges us to consider how and why we might want to expand or revise our understandings of the reading.

What is happening as I engage with the ideas in this text?

The first question that I ask students to pursue is: "What is happening as I engage with the ideas in this text?" As students read, they may utilize reading practices that they find helpful, such as underlining, annotating, or talking with the author(s) in the margins. These practices can help students track their emotional and intellectual responses to the reading. I ask students to keep notes in response to this question because it supports the class discussion that follows the individual reading experience. However, I do not require students to share this information with me. Because I care about students' authentic engagement with the reading, I do not want this part of the process to be shaped by their performance in class. Students often choose to share this information with me and their peers during the class discussion, but it is important to me that students have an opportunity to grapple privately with this question.

How am I making sense of these ideas?

As students document their responses to the first question, I also challenge them to account for their own positions and logics or assumptions by addressing the following question: "How am I making sense of these ideas?" In particular, I ask students to note the identities, lived experience, prior knowledge, or values that they bring to their reading of the text. In doing so, I ask students to articulate how they are constructing an understanding of the reading. Because this purpose for reading is often new to students, I model how I address these questions. I share, for example, how my lived experience as a multiracial person shapes my response to Baker-Bell's (2017) chapter. When sharing my examples, however, I am careful to explain that we may not be able to identify a direct cause and effect relationship. There are occasions when we cannot identify why we have particular responses or when the intersectional nature of our identities obscures a clear cause and effect response. Identifying the source of our responses with absolute clarity or certainty, however, is not the aim. Instead, we attempt to identify these relationships so that we can understand how our responses are constructed by a range of factors—rather than inevitable or neutral. Ratcliffe (2005) explains that "[s]tanding under our own discourses means identifying the various discourses embodied within each of us and then listening to hear and imagine how these discourses might affect not only ourselves but others" (p. 28). Individually and collectively, we imagine the connections between our lives and our readings. During the individual reading and class discussion, I ask students to share tentative responses to this question, which allows us to learn from each other and about the constructed nature of reading.

Why do readers make sense of the ideas in particular ways?

Ideally, the recognition that our responses to readings are constructed compels us to learn from others, particularly from readers who may construct their readings in different ways. To support this aim, I ask students to address the final question: "Why do readers make sense of the ideas in particular ways?" This question prompts students to identify any cultural logics that may play a part in the construction of their interpretations. During the independent reading and class discussion, this question allows students to closely examine claims in the reading—perhaps ones that garner emotional responses—and consider how those claims may function differently in different cultures. Through the process of rhetorical listening, students focus on the function of the claim *and* their response to the claim, as well as peers' responses. In her chapter, for example, Baker-Bell (2017) claims that "[t]he belief that there exists a homogenous, standard, one-size-fits-all language is a myth that is used to justify discrimination" (p. 99). This can be a hard claim for some students, especially for students who believe teaching standard written English creates equity. Rather than getting stuck in a

conversation about whether Baker-Bell is right or wrong, this question presses everyone to consider how this claim might function differently for different communities of language users or different educational stakeholders. Like the second question, this question can be difficult to pin down. The work to address this question, though, provides the deeper understanding of self and other that rhetorical listening seeks. Listening to others' understandings also helps us understand how and why we might revise our understandings.

Pedagogical Outcomes

The process that I have designed, one inspired by rhetorical listening, emphasizes accountability. Rhetorical listening posits that having a better understanding of each other helps us better communicate about the issues that impact us all. While there may not be a "right" or "wrong" way to respond to a reading, rhetorical listening is based upon the premise that we have a stake in each other's lives. We should listen to each other because our lives are interdependent; our choices impact each other. This emphasis on accountability makes us responsible for *how* we listen when we read a text. As we identify the ways our responses to readings are constructed, we become responsible for those constructions. My primary learning objective, then, is for students to recognize and grapple with the consequences that result from their constructions of readings. Such appreciation can support students' ability to discuss challenging readings for a course, but it can also support students' literacy development beyond the classroom.

In using and refining this process for 14 years in a variety of teaching contexts, I have observed three specific pedagogical outcomes. First, I have observed that making the constructed nature of reading visible through the practice of rhetorical listening repositions everyone in the classroom as a meaning-maker. All readers, including the educator, bring knowledge, beliefs, and goals to bear on a reading. As a result, the voices of all class members are important and valuable for deep exploration of the topic under discussion. While class participation is always a performance that is shaped by the dynamics of the classroom setting, this new purpose for reading reduces the need to avoid a reading or appease a teacher by offering a particular kind of response. This process allows me to communicate my desire to understand students' processes of engaging with the ideas in a reading, and I often notice evidence for this community building in class participation and final course evaluation comments. For example, one student "appreciated how close we were able to become as a class due to the way the class was structured." Another student commented, "I love getting to hear my peers' experiences and ideas through the class discussions that we often get to engage in." Students also thank me for the exploratory and problem-solving nature of our discussion by writing that the environment is "a welcoming, safe environment where pre−service teachers

can wrestle with their own thoughts and form their philosophies." These representative comments express students' perspectives on how this process creates a learning community.

Secondly, this process promotes critical self-reflection. Helping students "understand the role that their thoughts and feelings play…in making meaning," can help students become more critically self-reflective about the ways their own ideologies shape their engagement with readings (Critten, 2015, p. 154). It can help students understand, in other words, how ideology always shapes the activity of reading. Some of my favorite teaching moments occur when students recognize the limitations of their reading experiences. This recognition creates a need to learn from others. Frequently, my students report sharing a reading that we have examined in class with a friend or family member because they want to understand how someone they care about constructs meaning from the text. Other times, students continue to seek out additional perspectives beyond their local communities. After one student rhetorically listened to Baker-Bell's chapter, for example, she ordered the entire collection, *The Guide for White Women who Teach Black Boys*. As a white woman who planned to teach in a diverse setting, she recognized her need to learn from others with different backgrounds and experiences. In class, she explained how the practice of rhetorical listening revealed important gaps in her knowledge and perspective.

Finally, I have observed that this process can also support students' self-efficacy. According to Bui (2017), students' perceptions of a reading's importance can be linked to students' self-efficacy or their belief that they can learn from the material. Students can feel ill-equipped to publicly discuss the kinds of challenging topics that educators may want to explore. By providing a specific process for engagement with difficult readings, educators can support students' abilities to engage with the reading and affirm the importance of the reading. As a teacher educator, I often notice my students' appreciation for this process in their choice to replicate it with their students.

Conclusion

While this process will not eliminate all pedagogical challenges—students can still have all the same defensive responses—I find that it creates a more productive space for working with the range of responses students bring to their study of challenging course readings. Because the process prompts an investigation into our responses, it values the emotion that students sometimes feel that they must hide from educators and peers. Enacting rhetorical listening is an important pedagogical tool for the occasions when students' responses to the reading are central to the learning objectives. Of course, this means that educators who use rhetorical listening need to be open to these ideas. Rhetorical listening does not seek a particular

interpretation of a reading; instead, the focus remains on what happens when readers engage with readings. While classroom respect must remain at the heart of any productive learning space, exciting learning possibilities emerge when teachers and students have the opportunity to dialogue about the reasons why we engage with readings in particular ways. When we listen closely to each other, we can learn more about the beliefs, values, and assumptions that are central to engaging in conversations that matter.

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Implementation of a 25-minute Mini-lecture on Learning and Studying in Large-enrollment First-Year General Chemistry Courses

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Abstract

Poor results on the first exam in a course can be a shock to freshmen college students who found great success in high school. The experience can be demoralizing and put students in the mindset that academic success is out of reach. To convince such students that not only is academic success possible but readily achievable, I presented a 25-minute mini-lecture on learning and studying in two large-enrollment general chemistry courses (total N = 289) based on author Dr. Saundra McGuire's work. The mini-lecture discussed human learning and practical study tools. The purposes of the mini-lecture were to: 1) examine how well students could be convinced to critically assess their learning and study habits; and 2) motivate students to believe academic success is possible. I assessed the two goals via an anonymous survey utilizing Likert scale questions and essay questions. A majority (74%) of survey respondents who reported they watched the mini-lecture (N = 158) believed the mini-lecture assisted reflection on their study habits. Sixty-six percent of respondents reported changing their study habits. However, 38% of students who reported changing their study habits eventually reverted. When allowed to provide comments about the experience, students gave generally positive responses specifically citing how the mini-lecture prompted self-reflection and how the mini-lecture demonstrated the instructor cared about student success.

Keywords: higher education, first-year experience, undergraduate learning

The transition of students from their senior year of high school to their first year of college can be challenging due to the students being ill-prepared for the academic demands of higher education. Via a national survey of college freshmen, The Higher Education Research Institute reported that 57.8% of freshmen spent less than six hours each week on homework in high

school (Stolzenberg, Eagan, Romo, Tamargo, Aragon, Luedke, & Kang, 2018, p. 42), yet 96.9% received an average grade of B- or higher (Stolzenberg et.al., p. 27). This lack of preparation for the increased expectations of higher education can lead to unexpected poor performances on students' first exams during their first term. "The talk" often follows where instructors inform the underperforming students that they need to change how they approach learning and studying in order to succeed.

Instead of leaving students to struggle with this realization on their own, instructors can and should assist their students by showing them that approaches to learning and studying *can* change, and by providing specific guidance on *how* to change. This is the argument made by Dr. Saundra McGuire in the book *Teach Students How to Learn: Strategies You Can Incorporate Into Any Course to Improve Student Metacognition, Study Skills, and Motivation* (McGuire, 2013). McGuire believes a single 50-minute lecture given by a course instructor can convince students of the necessity of changing their learning and study habits. Once the students are convinced, the instructor can then provide tools to the students to facilitate the desired changes. McGuire, a chemist, believes this approach is effective regardless of instructional discipline.

McGuire's proposed lecture can be divided into three core components. The first is an opening with historical data of students who failed the first exam and then proceeded to earn A's or B's on subsequent exams to show improvement is possible. This discussion occurs in conjunction with reflection exercises on how current students in the course approach learning and studying. The second is a discussion of metacognition and Bloom's Taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) to provide possible explanations for why the students are struggling academically. The third is a description of tools students can use, such as institutional resources and studying techniques, to overcome these academic struggles. McGuire provides full PowerPoint presentations should an instructor not want to create one from scratch. Desiring to examine how this lecture could help my students, I administered a modified 25-minute version of the lecture to my CHEM 1210 (159 students) and CHEM 1220 (130 students) courses in the Fall of 2019. These courses are the first and second, respectively, of a two-semester general chemistry course sequence comprised primarily of first- and second-year students. The purposes of the mini-lecture were: 1) to examine how well students could be convinced to critically assess their learning and study habits; and 2) to motivate students to believe academic success is possible.

Methods

Due to time constraints and a desire to keep course content delivery consistent with other sections of CHEM 1210 held during the same semester, I distilled McGuire's 50-minute

lecture to a 25-minute mini-lecture. As recommended by McGuire, I presented the mini-lecture immediately after the grades for Exam 1 were released, and students were not warned of the mini-lecture ahead of time. The mini-lecture included discussion of:

1. The course-wide performance on Exam 1, with an emphasis on how some students might not have met their expectations
2. Historical Exam 1 to Exam 2 improvements by students in the course as evidence that significant improvement was possible
3. Metacognition, with an emphasis on how learning is a skill that can be trained and improved rather than an immutable inherent personal quality
4. Bloom's Taxonomy and of the greater expectations of college vs. high school as an explanation for why successful high school habits may not be successful in college
5. The Utah State University Academic Success Center (now Academic Success Programs) and how it provides resources to assist students in making changes to their study habits to improve academic performance
6. Two suggested study tools
    a. A study cycle (useable for all university courses), which I described as a structured way to regularly engage with and practice course content inside and outside of the classroom
    b. Regular low-stakes quizzes (specific to my course) that I explicitly state are designed primarily as feedback tools to help students prepare for exams, with a graphical depiction showing a clear correlation between quiz scores and course scores as evidence they work
7. A warning on how permanent changes in learning and study habits had to be made within 48 hours and consistently maintained or old habits would reassert themselves

The Supplemental Information to this manuscript contains an example set of the PowerPoint slides used in the mini-lecture.

The following week, I gave a brief reminder of this final warning at the start of the lecture. There was no further follow-up prior to Exam 2.

After Exam 2, I administered an anonymous survey to the course through Canvas, our institutional Learning Management System (LMS), to elucidate how well students retained the content of the learning and studying mini-lecture and to learn of student opinions on the mini-lecture. I categorized the mini-lecture's content into two components: human learning (metacognition, Bloom's taxonomy) and studying (institutional resources, study tools).

Results and Analyses

Multiple-choice questions in the survey used a Likert scale. The calculated percentage of respondent values are rounded to the nearest whole number and may not sum to 100%. Essay question responses are categorized by their contents and reported in aggregate. Some essay responses fit more than one category. CHEM 1210 enrolled 159 students and CHEM 1220 enrolled 130 students. 71% of CHEM 1210 students and 57% of CHEM 1220 students submitted the survey.

To determine how many students were exposed to the mini-lecture in some form, Question 01 asked if the respondent saw the mini-lecture either in person or via a recording. Ninety-three students (58% of total enrollment) in CHEM 1210 and 65 students (50% of total enrollment) in CHEM 1220 responded affirmatively (Table 1).

Table 1. *Summary of Student Responses to Survey Question 01*

Question 01: Did you attend or watch the recording of the mini-lecture on learning and studying given September 30? If you answer "No", please do not respond to the remaining questions and submit this evaluation now.

	CHEM 1210		**CHEM 1220**	
Student Response	**Number of respondents**	**% respondents (% total enrollment)**	**Number of respondents**	**% respondents (% total enrollment)**
Yes	93	82% (58%)	65	88% (50%)
No	20	18% (13%)	8	11% (6%)
No answer	0	0% (0%)	1	1% (1%)

Questions 02 and 03 investigated how well students believed they retained the information presented in the mini-lecture and provided the names of specific concepts to aid students in recall. Question 02 focused on the human learning concepts and asked students to rate how much content they retained on the following scale: 1 for "very little", 2 for "some", 3 for "most", and 4 for "all" (Table 2). Most respondents did not believe they retained a large portion of the human learning material. Eighty-three percent of CHEM 1210 respondents and 59% of CHEM 1220 respondents reported ratings of 1 or 2 with means of 2.0 and 2.4, respectively. These strong majorities of low retention level ratings may result from a lack of student interest in understanding the reasons behind why some study strategies may be more effective than others.

Table 2. *Summary of Student Responses to Survey Question 02*

Question 02: Please respond to this question only if you answered "Yes" to Question 01. How much do you remember about the discussion of human learning (metacognition, Bloom's taxonomy)?

	CHEM 1210		CHEM 1220	
Student Response	**Number of respondents**	**Percentage of respondents**	**Number of respondents**	**Percentage of respondents**
4 - Almost all of it	2	2%	6	9%
3 - Most of it	16	16%	21	32%
2 - Some of it	63	65%	31	47%
1 - Very little of it	16	16%	8	12%
No answer	16		8	
Mean value	2.0		2.4	

In contrast, respondents reported retaining more of the studying content as shown by their responses to Question 03 (Table 3). Using the same scale as Question 02, only 41% of CHEM 1210 respondents and only 40% of CHEM 1220 respondents reported ratings of 1 or 2. The mean values of 2.6 for CHEM 1210 and 2.7 for CHEM 1220 were both increases over the reported human learning retention mean values. This may indicate that students are more focused on practical tools and advice with tangible benefits to academic success rather than the theoretical underpinnings of those tools and advice.

Table 3. *Summary of Student Responses to Survey Question 03*

Question 03: Please respond to this question only if you answered "Yes" to Question 01. How much do you remember about the discussion of studying (Academic Success Center, Study Cycle)?

	CHEM 1210		CHEM 1220	
Student Response	**Number of respondents**	**Percentage of respondents**	**Number of respondents**	**Percentage of respondents**
4 - Almost all of it	12	13%	11	17%
3 - Most of it	42	44%	29	44%
2 - Some of it	34	36%	23	35%
1 - Very little of it	7	7%	3	5%
No answer	18		8	
Mean value	2.6		2.7	

Questions 04, 05, and 06 investigated how students used the information presented in the mini-lecture. Question 04 prompted students to report on whether they agreed that the mini-lecture assisted their reflection on their study habits and academic success (Table 4). Students rated their agreement using the following scale: 1 for "strongly disagree", 2 for "somewhat disagree", 3 for "neither agree nor disagree", 4 for "somewhat agree", and 5 for "strongly agree". Sixty-one percent of CHEM 1210 respondents and 73% of CHEM 1220 respondents reported ratings of 4 or 5 with a mean value for both courses of 3.8. This shows that many

respondents both performed a self-assessment of their study habits and believed the mini-lecture was valuable in that process.

Whether this self-assessment resulted in changed study habits was the focus of Question 05 (Table 5). Sixty percent of CHEM 1210 respondents and 71% of CHEM 1220 respondents reported they made changes to their study habits. The outcomes of Question 04 and 05 showed that a majority of respondents were convinced to critically assess their study habits and were sufficiently motivated to make changes to their study habits. However, this motivation was not persistent for all students. Of the 104 respondents between both courses who reported making changes to their study habits, 39 respondents (38%) reported reverting to their previous routines. This attrition echoes the warning in the final slide of the mini-lecture that stated changes in habits had to be maintained or old habits would reassert themselves.

Table 4. *Summary of Student Responses to Survey Question 04*

Question 04: Please respond to this question only if you answered "Yes" to Question 01. How strongly would you agree with the below statement? "The mini-lecture was helpful in reflecting on my study habits and what I need to do to succeed academically."

	CHEM 1210		**CHEM 1220**	
Student Response	**Number of respondents**	**Percentage of respondents**	**Number of respondents**	**Percentage of respondents**
5 – Strongly agree	14	15%	17	26%
4 – Somewhat agree	55	58%	31	47%
3 – Neither agree nor disagree	21	22%	10	15%
2 – Somewhat disagree	3	3%	5	8%
1 – Strongly disagree	2	2%	3	5%
No answer	18		8	
Mean value	3.8		3.8	

Table 5. *Summary of Student Responses to Survey Question 05*

Question 05: Please respond to this question only if you answered "Yes" to Question 01. Did you make changes to your studying habits as a result of what you learned in the mini-lecture?

	CHEM 1210		**CHEM 1220**	
Student Response	**Number of respondents**	**Percentage of respondents**	**Number of respondents**	**Percentage of respondents**
Yes, and continue today	34	36%	31	47%
Yes, but have stopped since	23	24%	16	24%
No	37	39%	19	29%
No answer	19		8	

While a majority of respondents made changes to their study habits, not all respondents did. To learn why some respondents did not change their study habits, Question 06 asked these respondents what would have made them more likely to change their study habits (Table 6). The question used a free-response format and the responses are categorized based on their content where some responses fit more than one category. In both CHEM 1210 and CHEM 1220, the most common reason to not change study habits was that the students were satisfied with their current study habits and were already succeeding in the course. Of the 56 respondents across both courses who reported not changing their study habits, 26 respondents (46%) reported being content with what they were already doing. While some of the other responses, such as better time management skills, were student-based and out of an instructor's direct control, an instructor could address some of the other responses. For example, integrating study tools directly into regular course content delivery would address the "a plan for students to utilize and assess studying changes" question response and the "in-lecture activities targeting changing study habits" question response.

Table 6. *Categorization of Student Responses to Free Response Question 06 for CHEM 1210*

Question 06 (Essay): Please respond to this question only if you answered "Yes" to Question 01. If you selected "Yes" to Question 05, leave this question blank. If you selected "No" to Question 05, please describe what could have been discussed that would have made it more likely you would actively seek to change your study habits.

Response Category	**Number of responses**		
	CHEM 1210	**CHEM 1220**	**Total**
Nothing because happy with current study habits	21	6	27
Access to additional resources (student-led help/tutoring)	5	1	6
Better personal time management	2	4	6
Response did not fit question prompt	1	5	6
A plan for students to utilize and assess studying changes	3	2	5
In-lecture activities targeting changing study habits	3	1	4
Suggestions on how to improve self-motivation or fully commit to change	1	3	4
Nothing because the content was previously learned and used	2	1	3
Don't know	3	-	3
Something to alleviate the fear that change would make things worse	1	-	1
Showing how better study habits result in a smaller time investment	1	-	1
Showing effects of better studying on student mental health	1	-	1

Making changes to study habits does not guarantee that those changes are successful and lead to greater academic success. Question 07 asked respondents that reported making changes to their study habits if they agreed that those changes helped them succeed academically (Table 7). Students rated their agreement using the following scale: 1 for "strongly disagree", 2 for "somewhat disagree", 3 for "neither agree nor disagree", 4 for "somewhat agree", and 5 for

"strongly agree". Sixty-three percent of CHEM 1210 respondents and 71% of CHEM 1220 respondents reported values of 4 or 5 with mean values of 3.7 and 3.9, respectively. This indicates that most respondents who made changes to their study habits believed they found greater academic success afterward. On the other extreme, only 5 respondents (4%) across both courses disagreed that the changes they made led to greater academic success. This information can alleviate fears that changes to study habits could make student academic situations worse. Respondents who made a change to their study habits generally found success as a result or, at least, were usually not harmed.

Table 7. *Summary of Student Responses to Survey Question 07*

Question 07: Please respond to this question only if you answered "Yes" to Question 01 and Question 05. How strongly would you agree with the below statement? "The changes I made to my studying habits helped me to succeed academically."

	CHEM 1210		**CHEM 1220**	
Student Response	**Number of respondents**	**Percentage of respondents**	**Number of respondents**	**Percentage of respondents**
5 – Strongly agree	11	15%	12	24%
4 – Somewhat agree	34	48%	24	47%
3 – Neither agree nor disagree	24	34%	12	24%
2 – Somewhat disagree	1	1%	3	6%
1 – Strongly disagree	1	1%	0	0%
No answer	42		23	
Mean value	3.7		3.9	

Question 08 provided respondents an opportunity to give feedback on the mini-lecture and its outcomes outside of the previous questions (Table 8). Responses were overall positive with the most common negative response being a belief that lecture time should not have been used to discuss learning and studying (n = 4).

By far the most prominent specific response across both courses was how the mini-lecture provoked self-reflection (n = 24). This is consistent with the results of Questions 04 and 05 that showed many respondents performed self-reflection on their study habits. The next most common specific response was that the mini-lecture showed the instructor was invested in student success (n = 17), which can be a powerful motivational tool to convince students to self-reflect and make changes to study habits. In terms of student reported practical outcomes, several students reported not just being convinced that they could improve (n = 9), but that changes they made resulted in greater academic success both inside (n = 6) and outside of chemistry (n = 3). Consistent with respondents stating in-lecture activities would have helped convince them to change their study habits in Question 06 (n = 4), several respondents stated a desire for regular discussions on learning and studying (n = 8) in Question 08. While this

would be difficult to incorporate into a course's normal curriculum, this could be an opportunity to point students toward institutional resources that already exist to assist students with these skills.

Table 08. *Categorization of Student Responses to Free Response Question 08 for CHEM 1210*

Question 08 (Essay): Please respond to this question only if you answered "Yes" to Question 01. Provide any comments you would like to make about the mini-lecture.

Response Category	**Number of responses**		
	CHEM 1210	**CHEM 1220**	**Total**
Provoked self-reflection on learning/study habits	13	11	24
Non-specific positive comment about the experience	11	7	18
Instructor cared about students/provided hope	8	9	17
Convinced students they could improve	3	6	9
A desire for regular discussions on learning/studying	4	4	8
Studying changes improved academic performance in this course	5	1	6
Good for freshmen/sophomores	3	2	5
Mini-lecture should have been held earlier in the term	2	3	5
The content was not applicable to the student	-	4	4
Lecture time should not have been used for this purpose	3	1	4
Comforting to know other students also had similar problems and help was available	3	-	3
Studying changes improved academic performance in other courses	2	1	3
Student wished they learned the content earlier in their academic career	1	2	3
Useful for setting proper expectations for college	2	-	2
Student regret at not implementing the suggestions	2	-	2
Request for more studying resources	1	1	2
Only this course discussed learning and studying among all of a student's courses	-	2	2
Holding after Exam 1 meant students would be more receptive	1	-	1
Reflection on how changing habits is difficult	1	-	1
More student interaction in the lecture would have led to higher content retention	1	-	1
Response did not fit question prompt	1	-	1
Students should already know how to study	-	1	1
Finding time to make changes is difficult	-	1	1

Conclusions

I presented a 25-minute mini-lecture on learning and studying to students in two general chemistry courses. Based on student responses to a survey administered after the mini-lecture, the mini-lecture prompted students to perform an assessment of their learning and study habits. In terms of mini-lecture content retention, students reported retaining mini-lecture information on human learning to a lesser extent than mini-lecture information on studying. A majority of respondents reported making changes to their study habits and many of them reported finding greater academic success after doing so. However, some students returned to their original study habits after a few weeks. Reported student opinions on the mini-lecture were mostly positive and specifically cited its helpfulness in self-evaluation and how it showed instructor investment in student success. Overall, the mini-lecture appears to have been a valuable experience for the students and succeeded in both convincing students to perform self-reflection and in motivating students to believe that academic success is possible.

One extension to the evaluation of the mini-lecture would be to identify what specific concepts students remembered. This information could be used to tune the lecture to more effectively connect the theory behind learning techniques to their practical outcomes in order to help students see the value of the background theory. An area for iteration of the lecture would be utilizing a full 50-minute lecture, as intended by McGuire, for a deeper discussion or a series of mini-lectures throughout the semester for continuous reinforcement. A more ambitious iteration would present similar mini-lectures or full lectures in other traditional first-year or second-year college courses in a coordinated fashion for broad reinforcement.

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Taking into Account Interpersonal Aspects of Teacher Feedback: Principles of Responding to Student Writing

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Abstract

Providing feedback on student work is a fundamental aspect of instruction and an important part of the learning process. A considerable amount of literature describes the pedagogical value of different types of feedback—explicit vs. implicit, comprehensive vs. selective, direct vs. indirect, and feedback on content vs. feedback on form—thus treating feedback primarily as an instructional/informational phenomenon. It must be remembered, however, that there is a real person behind each paper; therefore, interpersonal aspects of teacher feedback should not be disregarded. This article discusses five principles of responding to student writing that take into account this interpersonal nature of feedback: providing positive comments, avoiding appropriating student writing, responding as a reader, involving students in the revision process, and minimizing student frustration. The author suggests that these principles can help instructors deliver supporting and encouraging feedback that will be able to demonstrate their genuine interest in students' ideas, acknowledge students' efforts and writing progress, respect their voice and agency, and foster their growing motivation and self-confidence as writers.

Keywords: feedback, response to student writing, interpersonal aspects of teaching

> "[R]esponding to student writing entails more than deciding whether to comment on form or content; it involves delicate social interactions that can enhance or undermine the effectiveness of the comment and the value of the teaching itself" (Hyland & Hyland, 2001, p. 194).

Responding to student performance is an essential aspect of instruction and a vital part of the learning process (Hattie & Timperley, 2007). As Laurillard (1993) rightly noticed, "action without feedback is completely unproductive for the learner" (p. 61). Similarly, response to

student writing is an indispensable element of their writing development as well as their ability to produce independent written work. A considerable amount of literature is devoted to describing the pedagogical value of different types of feedback--explicit vs. implicit, comprehensive vs. selective, direct vs. indirect, and feedback on content vs. feedback on form. However, regardless of the significance of these "best practices" (Ferris, 2014, p. 7) for pedagogy, feedback is primarily treated as an instructional phenomenon, or, as Hyland and Hyland (2006) put it, "as *purely* informational, a means of channeling reactions and advice to facilitate improvements" (p. 206, emphasis in original).

As instructors[1], we need to remember, however, that each written paper has an author--i.e., a real human being who produced it. As such, the way feedback is received and processed may be influenced by interpersonal factors (Shvidko, 2018; Tobin, 1993; Värlander, 2008). According to Hyland and Hyland (2001), "Evaluation always carries with it the seeds of potential friction" (p. 194). Thus, the instructional value and purpose of feedback can be severely undermined, or, as Race (1995) put it, "eclipsed" (p. 67), by adverse reactions on the student part. I fully agree with Sommers (2013), who said, "The same comment can be phrased in different tones and often makes the difference between students feeling dismissed and insulted and students feeling respected and taken seriously" (p. 6). Therefore, teacher feedback--both *what* is said and *how* it is said--may have important implications both for students' writing development and their self-esteem, confidence, and motivation (Hyland & Hyland, 2006; Witt & Kerssen-Griep, 2011).

According to Hyland and Hyland (2006), response to student written work "not only communicates beliefs about writing, language, or content but also expresses and negotiates human relationships" (p. 222). Taking this interpersonal aspect of feedback into consideration, teachers need to provide encouraging, supporting, and motivational comments, which are not only useful from an informational point of view, but also beneficial for students from an affective standpoint. To this end, this article discusses five principles of providing feedback on student work that may not only promote student writing development but positively affect their agency, self-confidence, and motivation. These principles include providing positive comments, avoiding appropriating student writing, responding as a reader, involving students in the revision process, and minimizing student frustration.

[1] For the purpose of this article, the terms "instructor" and "teacher" are used to refer to those who perform instructional activities in formal educational settings, including teaching in the classroom and online, working with graduate students, and tutoring students one on one. Therefore, these terms are applicable to teachers, tutors, professors, and faculty, and they are the intended audience of this article.

Providing Positive Comments

Instructional feedback is sometimes described in the literature as inherently "face-threatening," as it implies evaluation/judgment of student work and even critique (Kerssen-Griep & Witt, 2012; Shvidko, 2018, 2020). As Trees, Kerssen-Griep, and Hess (2009) stated, "Even when combined with glowing comments about strong aspects of the students' work, suggestions about improvement inherently contain the message that students did not do as well as they could--and perhaps *should*--have" (p. 398, emphasis in original). Therefore, feedback messages may inadvertently "heighten emotional tension and pose identity threats" (Kerssen-Griep & Witt, 2012, p. 499) for students. This affective dimension of response to student writing is often overlooked because, as previously mentioned, it is often viewed from a fundamentally cognitive--as opposed to relational--lens.

Nevertheless, it is important for teachers to remember that negative feedback may potentially be discouraging for student writers and detrimental to the overall teaching-learning enterprise. For example, learner identity and self-esteem can be harmed by teacher negative evaluations (Carnicelli, 1980). Student motivation can also be shattered due to teacher criticism (Värlander, 2008). Furthermore, negative comments may potentially have a damaging effect on the learning process. Thus, as Witt and Kerssen-Griep (2011) stated, feedback "imposes on [students'] freedom to act and often negatively evaluates what they have done, which can provoke negative, unhelpful responses" (p. 79). Finally, even students' perceptions of the instructor--e.g., instructor's credibility--can be influenced undesirably by teacher response to their written work (Lee & Schallert, 2008; Witt & Kerssen-Griep, 2011).

While it is true that teacher feedback is intended to offer constructive criticism to facilitate student learning, it should also acknowledge positive aspects of student work and highlight the strengths of their writing. As Ferris and Hedgcock (2014) put it, "[I]t is human nature to desire and appreciate favorable responses to the work that we have done" (p. 242). Therefore, even simple positive remarks such as "*Well said*," "*Good point*," and "*Excellent example*," can build student motivation and confidence in their abilities as writers. By providing a "blend of encouragement and constructive criticism" (Ferris & Hedgcock, 2014, p. 240) in their written comments, teachers also validate student time spent on the assignment, thus making them feel respected and open to further feedback. It may not always be easy to achieve a balance between praise and criticism when commenting on student work, so in my own teaching, I found that responding as a reader, not only as a teacher (see below), helps me discover more positive features of student writing.

Avoiding Appropriating Student Writing

From my personal experience as a writer, I know that there is nothing more discouraging than comments that take over the writer's voice and creativity. From my teaching practice, however, I also learned that appropriating (i.e., taking over) student work oftentimes happens inadvertently. That is, in their best efforts to help students improve their papers, teachers may involuntarily impose too much control and authority--sometimes to the point that a student's paper looks like it belongs to the teacher. Then, as Severino (2004) pointed out, "students are confused or demoralized by having to puzzle out their teachers' expectations and write to fulfill them instead of writing from their own impetus and intentions" (pp. 50-51).

While it is obvious that taking over student agency and creativity is a negative practice, part of the teacher's job is to facilitate student learning by providing feedback that may include guidance, critique, and correction. How, then, can teachers distinguish between appropriating student writing and offering suggestions necessary for further improvement? Goldstein (2004) describes an important differentiation between appropriation and what she calls "helpful intervention" (p. 68), summarized in Table 1.

Table 1: *Difference between appropriation and "helpful intervention" (Goldstein, 2004).*

Feature of student text	Appropriation	Helpful intervention
Purpose	"commentary that ignores what a student's purpose is for a particular text and attempts either purposefully or accidentally to shift this purpose"	"commentary that shows a student where he or she is not achieving her/his purpose(s)"
Point of view	"commentary where a teacher demands that a student shift a position or a point of view"	"commentary that suggests a student read about a different point of view or interview others with a different point of view in order to know the other side"
Intended meaning	"commentary that "corrects" sentences or passages without asking the student about the intended meaning risks changing that meaning"	"commentary that asks students what they want to say and then helps students find the language to do so"

***Note*. Statements in Table 1 are taken from Goldstein 2004, p. 68.**

Writing experts offer numerous suggestions on how to avoid appropriating student work (e.g., Brannon & Knoblauch, 1982; Goldstein, 2004; Severino, 2004). I personally like to ask myself the following questions addressed by Joy Reid in her article "Responding to ESL students' texts: The myths of appropriation" (1994): "When might I interfere with their objectives or crush their creativity? In what ways might I assume control or ownership over their texts? What might I say that would deter them from becoming independent writers?" (p. 277). As a teacher, I learned that giving students power over their texts and a chance to exercise their writer agency and express their voice freely and proactively is crucial both for their writing

development and their evolving self-confidence and motivation. Some of the suggestions described below (i.e., giving students opportunities to challenge teacher comments, request specific feedback via reflective notes or memos, and discuss their papers in one-on-one conferences) may help to endow students with such power and control over their own texts, thus allowing their papers to fully reflect students' original voices.

Responding as a Reader

Teachers can also encourage and support student writers by responding to their texts not as an evaluator or an expert but as an interested reader (Sommers, 2013). According to Hyland and Hyland (2001), "By expressing their commentary as a personal response, […] teachers can make a subtle adjustment to the interactional context and perhaps foreground a different persona. It allows them to relinquish some of their authority and adopt a less threatening voice" (p. 198).

The key to responding as a reader is in showing students genuine interest in their ideas, thoughts, feelings, and experiences that students share through their written work. For instance, teachers can reply to students' experiences by sharing their own. They can relate to students' challenges by describing similar struggles of their own. They can also include affective comments in their responses, such as expressing surprise ("Who would have thought!" "Oh really?"), empathy ("That must have been challenging!" "That would make me sad too."), or disappointment ("That's too bad!" "How disappointing!"). Expressing this candid interest to the things students write about promotes relationships of trust and mutual respect, increases solidarity and prosocial connection, and makes feedback more authentic and meaningful (Shvidko, 2018). As Sommers (2013) put it, "Knowing that there is a real, live person--a teacher as a reader--at the end of the composing process imbues that process with meaning and significance that would otherwise be absent" (p. xii).

Involving Students in the Revision Process

Revision should not be "just a giver-receiver relationship with the teacher giving the information and the student receiving it" (Shvidko, 2015, p. 55); instead, it should be a collaborative endeavor. Such collaboration may stimulate student engagement in the revision of their writing, which in turn may help them grow into independent learners who are able to reflect on their development and make necessary changes for further improvement (Andrade & Evans, 2013; Benson, 2007; Ferris, 1995; Hyland, 2000; Milton, 2006; Shvidko, 2015). Research suggests that students' ability to reflectively analyze their writing may not only

increase their revision skills (Ferris & Hedgcock, 2014), but it can also promote their motivation (Lamb, 2001; Sommers, 2013), establish connections between writing instruction and students' academic and professional life in the future (Beaufort, 2007; Downs & Wardle, 2007), and cultivate self-regulated writers (Andrade & Evans, 2013). Therefore, it can be argued that involving students in the revision process facilitates their "long-term improvement and cognitive change" (Reid, 1993, p. 229).

Teachers can involve students in the revision process by helping them learn how to thoughtfully and meaningfully respond to feedback (Shvidko, 2015; Sommers, 2013). One of such methods is to encourage students to reply to teacher comments in the margins of a paper/writing assignment. Many computer programs allow for this function, so this strategy would probably work best when feedback is given electronically, although the classic "pen and paper" approach is possible as well. When commenting on teacher feedback, students can explain what revisions they made based on the feedback, ask questions about the comments they do not understand, or even challenge teacher remarks. Teachers can also give students the opportunity to argue their cases--for example, in a memo/note attached to their draft. In other words, when disagreeing with the feedback, students would explain why the comments were disregarded, and the expected revision was not made. Providing students with the opportunity to respond to feedback and even challenge it may promote students' engagement in "a dialogue about their writing" (Sommers, 2013, p. 9) and send them the message that the feedback should not be seen as the ultimate judgment of their work, and that the teacher is open to negotiation (Shvidko, 2020).

Along with encouraging students to respond to feedback, teachers can also engage them in the revision process by holding one-on-one writing conferences. The value of such conferences, whose purpose is to "transmit feedback and discuss potential revision" (Qureshi, 2013, p. 27), is in negotiation and collaboration that usually take place during this pedagogical activity (Gilliland, 2014; Martin & Mottet, 2011). Thus, writing conferences "allow students to exercise their agency by negotiating teacher feedback and standing up for their ideas" (Shvidko, 2018, p. 20). My own experience with writing conferences as a teacher demonstrates that these "dialogic encounters" (Consalvo, 2011, p. 30) are usually one of the students' favorite features of writing courses I teach. Most students appreciate the opportunity to discuss their writing face to face, ask questions and receive immediate answers, and clarify feedback. To facilitate their preparation for conferences, I usually ask my students to complete *conference preparation notes* (Appendix A). I noticed that completing these notes helps students reflect on their writing and be better engaged in the discussion.

Involving student writers in the revision process can also be achieved by encouraging them to reflect on and analyze their writing. By being immersed in the systematic analysis of their

own drafts, students become more attentive and reflective readers (Hamp-Lyons & Condon, 2000; Sommers, 2013). According to Ferris and Hedgcock (2014), self-evaluation[2] "builds confidence as students become more aware of their own strengths and of their abilities to help themselves" (p. 262). To this end, I like to implement a technique called *Letter to the Reviewer*, which facilitates collaboration between the teacher and the student. A *Letter to the Reviewer* is a short reflective note/memo submitted with each draft, in which students pinpoint both the strengths and weaknesses of their paper and request specific feedback that, from their perspective, would improve their draft (see Shvidko, 2015 for the description of this technique and examples of *Letter to the Reviewer*). Similar strategies are described in the literature as Dear Reader letter (Sommers, 2013), student-teacher memos (Sommers, 1988), writer's memos (Sommers, 1989), and process notes (Giles, 2010). To help students compose their letters/notes/memos, teachers can provide a list of questions/prompts to be used as a guideline (Appendix B). My experience with *Letter to the Reviewer* shows that students participate more actively and agentively in the collaborative revision process, become more reflective readers, and are able to better recognize the relationship between classroom instruction and their own written work. I also noticed that interaction developed through students' composing such reflective memos and teachers' responding to them increases interpersonal connections between teacher and student (Tobin, 1993) and encourages teachers to respond "to a *person* rather than to a script (Hyland & Hyland, 2006, p. 206, emphasis in original).

Minimizing Student Frustration

To provide supportive and helpful feedback, teachers should avoid responding to student writing in a way that would cause their frustration. Student frustration can be triggered by unclear and even cryptic comments such as confusing symbols (e.g., "?" "^"), abbreviations (e.g., "awk," "frag"), single-word questions (e.g., "transition?" "summary?"), vague remarks (e.g., "weak paragraph," "more evidence"), and writing/grammar-related jargon (e.g., "discourse-level transitions," "subject-verb agreement"), which not all students, and language learners, in particular, are familiar with. Feedback is most useful when it is understood by

[2] While not discussed in this article, self-evaluation, and more specifically self-editing, is a crucial skill that promotes student long-term writing development and helps them become independent writers. See Ferris and Hedgcock (2014) for an extensive discussion on strategy training for self-editing skills, as well as examples of practical activities teachers can implement to help students develop their self-editing skills.

To promote student independent assessment of their own writing, teachers can also introduce students to online self-editing tools and software, including grammar and plagiarism checkers.

students; therefore, teachers should try to comment on their work with complete sentences or detailed phrases that are clear, specific, and concrete. Along with clarity, feedback also needs to be legible. That is, if students receive hand-written comments, they should be able to read them effortlessly, instead of deciphering what the teacher has written.

Overwhelming comments are equally frustrating. When teachers comment on every single weakness of the paper, students may lose motivation and interest in writing, they may become "overly dependent on teacher feedback" (Ferris & Hedgcock, 2014, p. 242). Therefore, instructors should provide focused feedback by prioritizing features of student-written texts. The literature on writing feedback sometimes suggests responding to content (also called *higher-order concerns* or *global writing issues*) in earlier drafts and commenting on form/linguistic features of student work (also called *lower-order concerns* and *local writing issues*) in later drafts (Keh, 1990; Searle & Dillon, 1980; Zamel, 1985; also see Ferris & Hedgcock, 2014 for more discussion on the "content-form" dichotomy). Whether instructors choose to follow this model or provide a combination of feedback on content and linguistic issues of student texts, focusing on just a few characteristics/patterns of student writing would help to avoid overwhelming students with "commentary that may exceed the amount of text that students themselves have produced" (Ferris & Hedgcock, 2014, pp. 241-242).

Another important factor influencing student perception of teacher feedback--its transparency. Different instructors have different approaches to delivering feedback. A few examples of such approaches include focusing on content and topic development in early drafts and on linguistic characteristics of student papers in later drafts, formulating feedback as questions, affirmative statements, or imperatives; implementing marginal comments, end notes, or a combination of both; combining written feedback with other modes of responding to student work (e.g., conferences, audio comments). Similarly, teachers' expectations regarding student responses to feedback may also differ. Therefore, teacher philosophies about feedback, their approaches to responding to written work, and expectations from students should clearly be articulated to learners. In my own teaching practice, for example, I prefer to use categorized, color-coded feedback (Appendix C), which, as I discovered, helps students differentiate the purpose/point of each of my comments. I realize, however, that students may not be familiar with this method; therefore, I always give them an information sheet with the description of this approach and the list of color-coded categories of comments I use while responding to their writing.

Conclusion

As Sommers (2013) rightly noticed, "Our comments are written for specific purposes--to inspire, to encourage, to nurture, to evaluate--and are written to our students, who need respect and honesty, not harshness or mean-spiritedness" (p. 5). The evaluative function of feedback may sometimes overshadow its relational aspect and its inspiring, encouraging, and nurturing purposes, mentioned by Sommers. Unfortunately, it is possible for busy teachers to overlook this human dimension of the revision cycle and the fact that there is a real person behind each paper, and that every evaluative remark may have consequences of a personal and affective nature. As Hyland and Hyland (2006) suggested, "interpersonal aspects of response have the potential to construct the kinds of relationships that can either facilitate or undermine a student's writing development" (p. 209). This article highlights this very view of feedback and encourages teachers to remember that responding to student written work constitutes more than just commenting on content, language, and mechanics.

The above suggestions aim to provide instructors with further insight into the interpersonal--as opposed to informational--dimension of feedback. There is no single recipe on how to respond to student writing in a caring and supportive way. Therefore, this article only discusses five principles that can help teachers attend to the relational aspect of their feedback: providing positive comments, avoiding appropriating student writing, responding as a reader, involving students in the revision process, and minimizing student frustration. The principles described above may help instructors deliver supporting and encouraging feedback that will be able to demonstrate their genuine interest in students' ideas, acknowledge students' efforts and writing progress, respect their voice and agency, and foster their growing motivation and self-confidence as writers.

Ultimately, offering thoughtful and caring comments on student written work may contribute to the development of positive rapport (Lee & Schallert, 2008), whose pedagogical value is hard to overestimate (e.g., Frisby & Martin, 2010; Frisby & Myers, 2008; Frymier & Houser, 2000; Nguyen, 2007; Shvidko, 2020). Therefore, teachers should carefully consider their feedback--its content and the manner of delivery, and pay attention to the significance of their comments "in both providing helpful advice on […] students' writing and in negotiating an interpersonal relationship which will facilitate its development" (Hyland & Hyland, 2001, p. 208).

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Appendix A

Conference Preparation Notes (handout for students)

Name of Assignment: _____

Date of your conference: _____

Name: _____

Instructions: Carefully think about your current draft and things that you need most help with.

Please fill out this form and bring it to the conference.

My goal for the conference (Please be very specific):

Questions/comments I have about my draft (organization, ideas, etc.):

I have the following technical or computer-related problems or questions:

I have the following grammar-related problems or questions:

I have the following problems or questions about documenting sources (APA):

Any other comments/questions

Appendix B

Examples of Questions/Prompts for Letter to the Reviewer

Questions/Prompts for First Draft

- What are the strengths of your draft?
- What are the weaknesses of your draft?
- Does the draft have sufficient support or does it lack support?
- Is the organization of the paper effective? Briefly explain.
- What part of the draft is in most need of further work?
- What would you like your reader to pay close attention to while reading your draft?
- Are you expecting feedback on any particular elements of your draft? If so, what are they?

Questions/Prompts for Second Draft

- Briefly identify the major revisions that you have made in this draft based on the feedback that you received from your teacher and your classmate.
- What difficulties did you encounter while revising this draft? What was the most challenging part of revising this draft?
- What makes this draft stronger than the first one?
- In what ways does this revised draft better fulfill the purpose of the assignment than the first draft?
- What parts of this revised draft still need further work? Identify specific problems that you feel need to be addressed.
- Are there any particular places in your draft you want your reader to pay close attention to?
- Are there any language concerns (e.g., grammar, word choice) that you would like your reader to help you with?

Questions/Prompts for Final Draft

- Briefly identify the major revisions that you have made while composing this final draft.
- What difficulties did you encounter while working on this paper?
- What makes this final draft stronger than the previous ones?
- What are the major strengths of this final draft?
- Are there any weaknesses in this draft you want your reader to be aware of?

Appendix C

Categorized, color-coded comments for providing feedback

Categories of comments:

C: Content Comments that relate to the content of your essay, usually suggesting some revisions/additions in the content (e.g., ideas, supporting details).

O: Organization Comments about organization (e.g., flow of your ideas, paragraph structure, transitions words)

L: Language Comments that relate to linguistic elements of your writing, such as grammar and word choice.

F: Formatting Comments that relate to the format of your draft (e.g., spacing, font, documenting style)

R: Reader remark Comments that I make as a reader, not as a teacher. They are my "thinking aloud" comments, my reactions to your writing. These comments do not require any action from you.

Effect of Three Classroom Research Experiences on Science Attitudes

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Abstract

Here we evaluate undergraduate student attitudes about science after each of three authentic research experiences in a semester of an introductory biology laboratory course at Utah State University. The three course-based research experiences (CUREs) vary in length and student freedom, and they cover different areas of biology. Students responded to the science attitude items of the CURE Survey. When compared to national data, our students faired similarly, and all students struggled with certain epistemic assumptions about science knowledge. As also seen in the national database, change in science attitude was slight and nonlinear. Student self confidence in what a career scientist is and in scientific process skills was the best predictor of scientific maturity, not the three CUREs or other aspects of students' background. We discuss the slight positive and negative change in attitude we did influence, and we note that most students would choose to have another research experience.

Keywords: CURE, undergraduate students, introductory biology

Background

Over the last decade and as a result of calls for reform in undergraduate biology education, many universities have updated their scientific laboratory courses to emphasize course-based undergraduate research experiences (CUREs; Auchincloss et al., 2014). CUREs replace "cookbook" laboratory exercises in which students can guess or figure out the result(s) before conducting the exercise. Instead, CUREs help students fill real gaps in our scientific knowledge, as practicing scientists do. Thus, during a CURE, students experience all or some of the process of science: reading and evaluating the scientific literature, asking authentic questions, selecting the appropriate methods, collecting and analyzing data, interpreting and disseminating results, and working collaboratively. This authentic experience means that the students' work has meaning beyond the particular course. CUREs fit under the umbrella of situated-learning theory, which proposes that learning involves a group of people working on

a common problem and using a common set of practices, where learning is doing and belonging (Lave & Wenger, 1991).

Studies have looked at the benefits of CUREs (e.g., Denofrio et al., 2007; Kowalski et al., 2016; Flaherty et al., 2017a). CUREs allow all students to participate in authentic research, not just high-achieving or upper-division STEM college majors with internships. This way, students who have not declared their major can experience authentic research, and the early-on experience may help retain students in the STEM fields (Harrison et al., 2011). The experience might be a first encounter in taking responsibility for their own learning (Lopatto & Tobias, 2010), and a sense of ownership can contribute to their persistence in science (Hanauer et al., 2012). CUREs can help students self-identify as a scientist and improve their understanding of science as creative and process-based (Russell & Weaver, 2011; Indorf et al., 2019). A general finding is that students in a research-like science course report learning gains that resemble those reported by students in dedicated research experiences, with the magnitude of these gains falling between the higher ratings of undergraduate researchers and the lower ratings of students in more traditional courses (Lopatto & Tobias, 2010).

Current need

In 2016, we updated the undergraduate-level Biology I Laboratory course at Utah State University (BIOL 1615 at USU) by replacing prescribed exercises with three CUREs. Now, students practice discovery-based (descriptive) science in this course (students gain experience with hypothesis-driven science in the second semester of the introductory biology lab course series, Biology II Laboratory). Nationwide, there are: 1) multisite CUREs in which data collected by students across institutions feed into a national database, such as the SEA-PHAGES program (Hanauer et al., 2017), and 2) projects led by individual instructors. Our CUREs are a mixture of both, and we refer to them with the following names: science garden (CURE 1), endophyte diversity (CURE 2), and bee immune systems (CURE 3) (Figure 1). After practicing descriptive science during short stand-alone guided inquiry projects the first few weeks of the semester, students participate in the first CURE. During one class session, students work on a long-term project in the Dr. Gene Miller Life Science Garden Laboratory in which they measure plant traits and quantify changes across populations over time. CURE 1 is based on and uses the plants from a funded, National Science Foundation (NSF) project led by Z. Gompert. The week after CURE 1, students start CURE 2. In CURE 2, students discover fungal endophytes growing in plant tissue on campus and discover the evolutionary relationships among them. This project was adapted from Bascom-Slack et al. (2012). Students choose which plant tissues to sample from after exploring what is known in the scientific literature and thereby what gaps still need to be filled. CURE 2 runs for seven weeks and is

directly followed by CURE 3. In one class session, students quantify the immune response of native bees from Panama to test a hypothesis regarding life history trade-offs, designed by a resident graduate student, F. K. Hunter. In Table 1, we list the inquiry characteristics of each experience. All three experiences are inquiry-based and authentic, because the results are not known upfront and the research is relevant to the scientific community, respectively. The amount of freedom students have to make decisions about the project varies, with CURE 2 giving students the most freedom. Across the country, CUREs have been developed around faculty research, but most focus on one research area (but see Indorf et al., 2019). Our series of CUREs exposes students to multiple areas of biology: population biology, systematics, and animal behavior. We view applying the scientific process to different areas reinforces research skills and students' understanding of the process of science. Furthermore, if students do not connect with one research area, they may appreciate another.

Figure 1. A visual for each USU BIOL 1615 CURE during fall 2019. From left to right, in order of occurrence: 1) students working in the Dr. Gene Miller Life Science Garden Laboratory during CURE 1 (photo by N. Bresee, USU College of Science), 2) a sample of cultured endophytes during CURE 2, 3) the bottom right hole within the dish shows a zone of inhibition where bacteria are not growing around the antimicrobial solution from a bee's thorax during CURE 3.

Table 1.

Inquiry characteristics of the CUREs in BIOL 1615 at USU. Indorf et al. (2019) provide a similar table.

Inquiry characteristics	**CURE 1: Science Garden**	**Cure 2: Endophyte Diversity**	**Cure 3: Bee Immune Systems**
Question type	Novel	Novel	Novel
Source of the question	Given by instructor	Open to student (who uses the scientific literature)	Given by instructor
Data collection methods	Given by instructor	Given by instructor	Given by instructor
Analysis of data	Open to student	Given by instructor	None
Iteration of scientific process	Students analyze previous years' data	Students critique one another's work	Students use a graduate student's hypothesis
Type of equipment used	Advanced (e.g., InsectaZooka)	Advanced (e.g., DNA sequencing)	Advanced (e.g., zone of inhibition assay)
Data quality	Potentially publishable	Potentially publishable	Potentially publishable
Presentation of results	Reflection submitted to instructor	Peer-reviewed lab report	None (graduate student uses the raw data)
Length of project	1 class session	7 class sessions	1 class session

We have had an updated BIOL 1615 curriculum for four years. Here we make an important first step in assessing the CUREs in this course. We address the following questions: 1) How do our students' attitudes about science compare to average attitudes nationwide?, and 2) How are attitudes affected by each CURE within this one-semester course? Most past studies conducted a single pre and post-course survey, whereas we conducted a pre-course survey and one survey after each of the three CUREs. Checking in with student attitudes multiple times in a semester could be enlightening. As attitudes can be affected by other factors, such as family background, age or grade level, and gender (Perera et al., 2017), we also look into some other factors, besides the CUREs, that might explain student attitudes about science.

Methods

The institutional review board of USU approved the procedures of this study (IRB #10534).

The course context

In the fall 2019 semester of BIOL 1615, there were 884 students enrolled in 39 lab sections, with a maximum of 24 students per section. There were 16 graduate teaching assistants (GTAs) that taught the lab sections. Most GTAs taught three lab sections. A lab coordinator, L. K. Lucas, trained the GTAs in general scientific teaching practices and lab project logistics

during an hour per week. The course met 2.75 hours per week. Students were in semester-long groups of three or four. Each group had their own table where they faced each other to facilitate collaboration. Each week, students were asked to read the lab manual and complete a pre-lab quiz to prepare for class. Students received a brief in-class presentation by their GTA to emphasize background information commonly missed on the pre-lab quiz, safety rules, and complicated procedures.

The survey: informed consent

We conducted four surveys: the pre survey, the post CURE 1 survey, the post CURE 2 survey, and the post CURE 3 survey. Each survey started with an explanation of the purpose of the project and the informed consent (Supplemental Information: Methods). The consent explained that participants were required to be at least 18 years of age and participation was voluntary and anonymous. The incentive for participation was a raffle for each of the four surveys. Four raffle winners total were each given a $25 Amazon gift card. We created our surveys in Qualtrics. We created "anonymized raffles" with the "anonymize response" option to remove all personal data, including IP address. If a student agreed to entering the raffle, they entered an email address. Only F. K. Hunter had access to the email addresses. She randomly chose one email address for each of the four surveys using the 'randomNames' package in R. The pre survey was available to students the week of September 9, 2019. The post CURE 1 survey was available to students the week of September 23, the post CURE 2 survey was available to students the week of November 25, and the post CURE 3 survey was available the week of December 9.

The survey: content

Most studies reporting assessment of CUREs in the life sciences have made use of the Classroom Undergraduate Research Experiences (CURE) Survey (Lopatto, 2007; Lopatto & Tobias, 2010). The CURE survey has thus far been administered to more than 10,000 students at 122 different institutions nationwide. We adopted parts of it for our study because this wide use affords us a strong comparison with other courses and programs. There are other science attitude surveys in the literature but have less representation: the Views about Sciences Survey (Halloun & Hestenes, 1996) and the Views on Science and Education Questionnaire (Chen, 2006), for example. First, students answered questions about their background: gender, ethnicity, status in school, major, whether they had participated in research before this course, and current plans post-undergraduate degree. Next, we asked students for their perceptions

of their performance on aspects of the process of science (originally derived from other well-known surveys such as the CIRP Freshmen survey; Astin, 2003).

Last, students responded to a series of Likert-type items regarding their attitudes toward science, originally written by Wenk (2000). The items were designed to be balanced between negatively and positively structured (that is, whether agreeing or disagreeing constitutes the more complex thinking). Some of the questions were specifically written to: 1) address epistemic assumptions about science knowledge, which range from believing knowledge can be known concretely to understanding knowledge is created in context and is subjective, 2) address methods of justifying decisions, and 3) get a sense of the degree to which individuals see themselves as exerting power or control in creating scientific meaning or of being in control of their learning in science (also known as students' sense of agency with regard to science). Table 2 lists the 22 attitudes about science items, the known justification for the question, and the answer expected for a "scientifically mature" student, according to Wenk (2000). The three post CURE surveys included two questions at the end: one that asked if they would choose to have another research experience, and the other asked for comments regarding how the specific CURE affected their attitude about doing science. We decided not to use the part of the CURE Survey that relies on student perceptions of their own skill gains, as we worry about overconfidence in self-reporting (Kardash, 2000).

Table 2.

Attitudes about science Likert-type survey items, followed by their known justifications, and the expected answers for a mature student (+ means stronger agreement, - means stronger disagreement; Wenk, 2000). PC 1 loadings are positively correlated with expected answers (see text), and the βs and p-values are given in parentheses for the items that significantly changed after each CURE (☑ means the change was in the expected direction, ☒ means the change was in the unintended direction).

Order	Item	Justification	Expected answers	PC1 loadings	CURE 1	CURE 2	CURE 3
1	Even if I forget the facts, I'll still be able to use the thinking skills I learn in science.	sense of agency	+	0.17			☒ (-0.34; 0.009)
2	You can rely on scientific results to be true and correct.	epistemic assumptions	-	0.04			
3	The process of writing in science is helpful for understanding scientific ideas.		+	0.15			
4	When scientific results conflict with my personal experience, I follow my experience in making choices.	methods of justifying decisions	-	-0.19	☑ (-0.26; 0.03)		

5	Students who do not major in science should not have to take science courses.	sense of agency	-	-0.27		☒ (0.29; 0.05)	
6	I wish science instructors would just tell us what we need to know so we can learn it.		-	-0.36			
7	Creativity does not play a role in science.	epistemic assumptions	-	-0.28			
8	Science is not connected to non-science fields such as history, literature, economics, or art.		-	-0.30		☒ (0.28; 0.05)	
9	When experts disagree on a science question, it's because they don't know all the facts yet.	epistemic assumptions	-	-0.12			
10	I get personal satisfaction when I solve a scientific problem by figuring it out myself.	sense of agency	+	0.18		☒ (-0.28; 0.009)	☒ (-0.39; 0.004)
11	Since nothing in science is known for certain, all theories are equally valid.	epistemic assumptions	-	-0.16			
12	Science is essentially an accumulation of facts, rules, and formulas.	epistemic assumptions	-	-0.20			
13	I can do well in science courses.	sense of agency	+	0.24		☒ (-0.39; <0.001)	☒ (-0.33; 0.008)
14	Real scientists don't follow the scientific method in a straight line.		+	-0.09			
15	There is too much emphasis in science classes on figuring things out for yourself.	sense of agency	-	-0.34			
16	Only scientific experts are qualified to make judgements on scientific issues.	epistemic assumptions & sense of agency	-	-0.26			
17	Scientists know what the results of their experiments will be before they start.	epistemic assumptions	-	-0.17			
18	Explaining science ideas to others has helped me understand the ideas better.		+	0.11			
19	The main job of the instructor is to structure the work so that we can learn it ourselves.	sense of agency	+	0.16			
20	Scientists play with statistics to support their own ideas.	epistemic assumptions	-	-0.26			

21	Lab experiments are used to confirm information studied in science class.		-	0.01		☑ (-0.38; 0.005)	
22	If an experiment shows that something doesn't work, the experiment was a failure.		-	-0.19			

Data analysis

As survey question responses did not have numerical values, we coded the data before analysis. We coded the following responses as binary: gender (female vs. male, because no other answers were given), ethnicity (white vs. all others, because diversity was so low), major (biology vs. all others, because biology majors may be most invested in the course), previous research experience (none vs. any), and plans after undergraduate degree (graduate school vs. other plans, because those planning on graduate school may be more engaged in academics). Status in school was converted to an ordinal 1-5 scale (first year, second-year, third-year, fourth or more-year, graduate student). Answers to the question "When someone discusses a "career scientist", how easy is it for you to visualize a career of that sort?" were also converted to a 1-5 scale (no clue, vague idea, not confident, good idea, very clear idea). We converted students' perceived relative level of scientific skill to a 1-5 scale and summed responses to six questions, as a measure of self-confidence (minimum score 6, maximum score 30). The attitude about science questions were converted to a 1-5 scale as well.

We first determined the extent to which the 22 science attitude responses were correlated with each other within our dataset. We conducted a principal component analysis (PCA) using the 'prcomp' function in R (version 3.3.2). We centered (mean = 0) but did not scale the responses, instead opting to retain differences in variability among them. To answer our first question regarding how our students' attitudes about science compared to average attitudes nationwide, we calculated means, standard deviations, and standard errors for each of the 22 science attitude items for each of our four surveys, to compare to each other and Lopatto's nationwide data (unpublished data, N=18,062).

To answer our second question, how are attitudes affected by each CURE within this one-semester course?, we performed linear regressions using the 'lm' function in R (version 3.3.2). Our covariates were: post CURE survey number (coded as a binary indicator variable for each survey), gender, ethnicity, status in school, major, previous research experience, graduate school plans, confidence in what a career scientist is, and confidence in scientific skills. We

ran a linear regression with the response variable as principal component 1 (PC 1) from above, as well as for each of the 22 science attitude items.

Results

We discarded surveys that were not complete (specifically, those in which the student did not respond to the last science attitude item). Between 30 and 203 students completed each survey, with the highest response rate for the first survey (23% of students responded to the pre survey, 10.5% responded to the post CURE 1 survey, 6.1% responded to the post CURE 2 survey, 3.4% responded to the post CURE 3 survey; Table 3). The average student spent about five minutes on the survey (s.d. = 179). Our respondents were female-biased (relative to a 50:50 sex ratio), much like found in the nationwide data. Dissimilar to the nationwide data, our student population was less diverse ethnically and dominated by first-year students, and fewer (a little over half) were planning on attending graduate school. About 20% of respondents were biology majors, and roughly half of respondents had some kind of research experience prior to this course (Table 3). Compared to the nationwide dataset, our students were not as confident in visualizing a career scientist (roughly a third could vs. half of students nationwide), but we saw improvement in this aspect across our surveys. Last, average students' perceptions of their scientific skills levels were steady across the four surveys, with an average score of approximately 22 out of 30 (Table 3).

Table 3.

Background of the survey participants. The proportions reported are based on the total number of students that completed the surveys (answered the last science attitude question). Some comparisons to nationwide data (Lopatto, unpublished data) are available.

	Pre	**Post 1**	**Post 2**	**Post 3**	**Nationwide Pre-Course Survey**	**Nationwide Post-Course Survey**
Started survey (N)	219	104	55	34	18,062	18,062
Completed survey (n)	203	93	53	30	Depends on question	Depends on question
Median time spent on survey (in seconds)	303	290	292	274.5	NA	NA
Proportion female	0.63	0.67	0.70	0.67	0.646 (n=17,810)	0.646 (n=17,810)
Proportion non-white ethnicity	0.10	0.07	0.02	0	0.595 (n=17,638)	0.595 (n=17,638)
Proportion first-year undergraduate	0.67	0.61	0.55	0.70	0.341 (n=17,889)	0.341 (n=17,889)
Proportion majoring in Biology dept.	0.24	0.22	0.19	0.23	NA	NA
Proportion participated in any research before this course	0.38	0.51	0.64	0.63	NA	NA

Proportion planning on graduate school	0.61	0.59	0.55	0.73	0.94 (n=17,014)	0.858 (n=15,854)
Proportion who can visualize a career scientist	0.21	0.33	0.45	0.37	0.52 (n=3,296)	NA
Average confidence in scientific process (max = 30)	21	22	22	23	NA	NA

We conducted a principal component analysis (PCA) with all 22 science attitude items with all surveys pooled (the data do not segregate by survey type; Supplemental Figure 1). The first principal component (PC 1) explained 18.4% of the variance in the data, and PC 2 explained an additional 8.84% of the data. Thereafter, there was a steady decline in the proportion of variance explained (PC 3 explains 7.14%, PC 4 explains 6.74%, PC 5 explains 6.26%, etc.). The PC 1 loadings (Table 2) were positively correlated with the responses expected from scientifically mature students (i.e., those with more complex thinking), as described in Wenk (2000) ($r = 0.82$ (95% CI: 0.61-0.92), $R^2 = 0.68$). We will refer to PC 1 as a measure of scientific maturity hereafter.

We compared our students' mean responses to the attitudes about science statements: 1) to the mean scores of the nationwide data, 2) to the expected response for a scientifically mature student, and 3) across the four surveys we administered (for plotting purposes, all negative responses were reversed to positive in Figure 2; Supplemental Table 1). We will focus on the first two comparisons in this paragraph. The 95% CIs for our students' mean responses overlapped the nationwide pre-course or post-course means or both in most cases but were different from the national averages in six cases. Our students exceeded the national average on four items: 1) creativity does not play a role in science (item 7), 2) since nothing in science is known for certain, all theories are equally valid (item 11), 3) only scientific experts are qualified to make judgements on scientific issues (item 16), and 4) if an experiment shows that something doesn't work, the experiment was a failure (item 22). Our students fell below the national average on two items: 1) you can rely on scientific results to be true and correct (item 2), and 2) when experts disagree on a science question, it's because they don't know all the facts yet (item 9). Most mean responses, ours and nationwide, to the attitude statements were in the expected direction (i.e., expected for scientifically mature students, near a mean score of 3, at least, or above, in Figure 2). However, there were three items that USU and nationwide students responded to unexpectedly (below 3, in Figure 2): 1) you can rely on scientific results to be true and correct (item 2), 2) science is essentially an accumulation of facts, rules, and formulas (item 12), and 3) lab experiments are used to confirm information studied in science class (item 21).

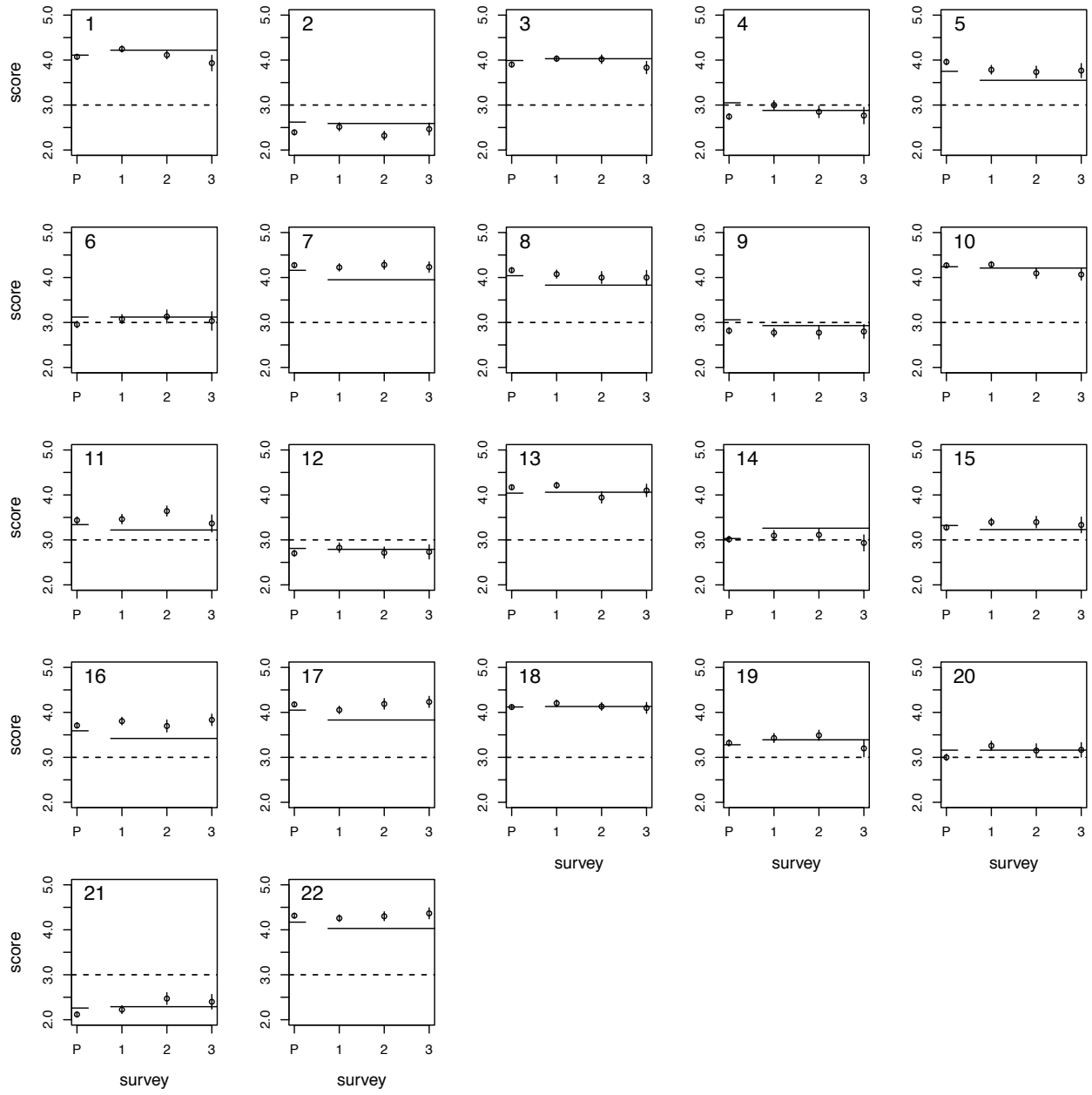

Figure 2. Mean scores (circles) and standard errors (small vertical lines through circles) for each science attitude survey item (1-22) for each of our administered surveys (P = pre survey, 1 = post CURE 1 survey, 2 = post CURE 2 survey, 3 = post CURE 3 survey). We reversed the scores for items with an expected negative response. Horizontal dashed lines are at a score of 3, which is a neutral response; we expect scientifically mature students to be near a score of 5. Solid horizontal lines are mean scores from data collected nationwide (standard errors are not shown because samples sizes per item were high and ranged from 17,284-17,950; Lopatto, unpublished data). The nationwide pre-course means are placed at "P", and the nationwide post-course means are placed at 1-3 along the x-axes.

Changes in mean responses to the attitudes about science statements across the four surveys were slight (see four circles in each plot of Figure 2), which is similar to the differences seen in the nationwide pre- and post-course means (horizontal solid lines in each plot of Figure 2). In some cases, the nationwide means increase from pre- to post-course survey, that is, students' attitudes towards science improve (e.g., a 0.11 difference in means in plot 1 of Figure 2), but more often they stay the same or decrease (Figure 2; Supplemental Table 1). One might expect to see a steady increase in means across our surveys if students' attitudes about science improved after each authentic science experience, but the slight changes in means across our four surveys were not linear. Thus, in our linear regressions, we treat each CURE in the course as an independent experience (i.e., a categorical factor), not contingent on the previous CURE.

When we performed a linear regression with PC 1 as the response variable, we learned that student's confidence in what a career scientist is (β: 0.38, p-value < 0.001) and their confidence in the process of science skills (β: 0.13, p-value < 0.001) were the biggest predictors of their scientific maturity, not the CUREs or the other covariates ($R^2 = 0.16$). Whereas looking at PC 1 is a reasonable way to distill the science attitude items into one variable, we also ran a linear regression for each of 22 science attitude items and focused on the items that significantly changed as a factor of the CUREs (Supplemental Table 3 has βs and p-values for all covariates and response variables and R^2 for each model). One item, "when scientific results conflict with my personal experience, I follow my experience in making choices," changed significantly in the expected (negative) direction after students completed CURE 1 (a 0.26 difference in means from the pre survey, Supplemental Table 1; $R^2 = 0.05$, Supplemental Table 2). After CURE 2, the response to five items changed significantly (Table 2), but only one in the expected (negative) direction: "lab experiments are used to confirm information studied in science class" (a 0.39 difference in means from the pre survey, Supplemental Table 1; $R^2 = 0.05$, Supplemental Table 2). Lastly, three items changed after CURE 3, all of which were in the unintended direction (Table 2; Supplemental Table 2). Two items changed in the unintended direction in both CURE 2 and CURE 3: "I get personal satisfaction when I solve a scientific problem by figuring it out myself" and "I can do well in science courses."

Across the semester, roughly three quarters of survey respondents said they were likely or very likely to choose another research experience (88% of students after CURE 1, 79% of students after CURE 2, and 73% of students after CURE 3). A number of students made open-ended comments about each CURE (n = 27, 24, and 10, respectively). For each survey, more positive comments were made than neutral or negative comments (Supplemental Table 3). Some students appreciated that so many students were able to do real field work right outside of the classroom building during CURE 1, while one student was disappointed that they mainly experienced data collection and not the other steps of the scientific process. Some students found CURE 2 gave them needed practice with writing about all steps of the process

of science and a better appreciation of what it takes to publish research, while others wished the activities in the lab directly supported what they learned in the introductory biology lecture course. Some students liked working with an animal system in CURE 3 (CURE 1 and 2 were plant and fungus projects, respectively), while others did not end up seeing the connection between the methods performed and the graduate student's hypothesis.

Discussion

We had more post-CURE respondents that felt comfortable visualizing a career scientist than pre-CURE respondents. The CUREs varied in theme, freedom, and length. About three-fourths of respondents to all three post CURE surveys would likely or very likely choose to seek out another opportunity to do authentic science. Each CURE elicited more positive comments than neutral or negative. Some comments eluded to an appreciation of the variety of CUREs offered in the course. Our results were also sobering. First, student self-confidence, in accurately visualizing a career scientist and in their performance on parts of the process of science, was the greatest predictor of scientific maturity, not the CUREs in BIOL 1615. Second, overall, little change in science attitude was seen after each CURE. But when looking at each of the science attitudes items separately, we do seem to have a positive influence over specific aspects of students' science attitudes, whether the CURE is short or long. Specifically, we can help students make decisions based on scientific results, even when they conflict with personal preconceptions, and see that science is more than learning content in a large lecture-style classroom. We also have the ability to negatively affect students' science attitudes, especially when it comes to their satisfaction with solving problems on their own and their ability to succeed in science courses in general.

Comparison to similar research

Other researchers have seen little change in science attitude across a course, too. Wenk (2000) compared attitudes between students who experienced scientific inquiry vs. students who worked on content mastery during a semester. The overall direction of change on the epistemic assumptions about science knowledge items was in the negative (unexpected) direction. But when looking into the details, Wenk found that students in the content mastery group shifted to greater comfort with uncertainty in science but reported less curiosity about science and a greater belief that science courses are important only to science majors. Students in the inquiry group were perhaps more apt to be persuaded by scientific results. Hunter et al. (2007) found epistemological beliefs tend to remain stable in science undergraduate research experience (URE; similar to a CURE but typically a longer research experience) participants

interviewed repeatedly over several years. These findings, with ours, suggest that the epistemological beliefs of undergraduate science students do not shift rapidly, however, some programs have documented significant change in student insight into the process of science and their beliefs about learning in a single semester (e.g., the C.R.E.A.T.E. program that uses intensive analysis of primary literature to demystify science; Hoskins, et al., 2011). Perera et al. (2017) summarizes other studies and concludes that changing students' attitudes toward science, in the short or long term, is not straightforward.

Other researchers have distilled the 22 science attitude survey items into one or two variables, and their results are similar but not exact to ours. We view PC 1 as an overall measure of scientific maturity (as in Wenk, 2000). Perera et al. (2017) used factor analysis for variable distillation and found one factor that assessed whether students value learning science, which corresponded to some of our high positive PC 1 loadings. Another factor they found indicated whether the students likely had a more advanced understanding of how science works and what it means to do science, and these items all had low negative PC 1 loadings in our study. Lopatto (unpublished data) found five of the science attitude items positively correlated with student-reported learning gains (items 1, 3, 10, 13 and 18, all of which had high positive PC 1 loadings in our study).

We retained the original wording of the items from Wenk (2000) for comparison purposes, but Perera et al. (2017) reworded nine of the items as informed by results of an expert review at their university. They revised the items to clarify them without changing their initial meanings, including the three items students, across the board, struggled with the most (items 2, 12, and 21). For example, instead of "you can rely on scientific results to be true and correct," they said, "the purpose of science is to identify true facts." It is unclear how the revised wording might have affected our students, however, Perera et al. (2017) found that factor analyses with and without the reworded items changed the exact factor loadings but not the groupings themselves. The struggle with these three particular statements might be more associated with students having more experience with learning scientific facts than engaging in science (Wenk, 2000). We promote teaching science via inquiry to give students the opportunity to learn that science is a complex endeavor that always involves uncertainty, an uncertainty that does not undermine science's usefulness in making decisions.

Future directions

We plan to use our results to inform how we train the graduate teaching assistants (GTAs) that mentor and guide the students in this course. The GTAs are asked to point out to students that things do not always work as anticipated, a reality of "real" science. We consciously design our CUREs in a way that balances reaching successful results with providing real,

unpredictable science; for example, if students do not successfully culture endophytes in CURE 2, we have back-up endophytes to sample from. We do not penalize students for the unexpected but evaluate their interpretation of it. But perhaps more can be done to keep students from equating setbacks in the process of science with their overall performance in science courses (Indorf et al. (2019) experienced similar student dissatisfaction). Our next step is to shift the focus of our GTA teacher training from logistics to teacher empowerment. We will emphasize the importance of the CUREs as an instructional technique and the significance of GTAs' potential to enhance the undergraduates' research experiences (similar to Flaherty et al., 2017b). We will survey the GTAs to better understand the challenges GTAs face leading these introductory biology CUREs (similar to Heim & Holt, 2019), to better help them overcome the challenges. Good interactions between students and instructors can have many benefits, from navigating the uncertainty inherent in science research to connecting students to networks that promote their career development (Auchincloss et al., 2014).

We hope our students are gaining at least a little more confidence in doing science during these CUREs, which could lead to more positive attitudes when faced with real science in the future. Given that most respondents to our surveys want more research experiences, we will continue to encourage other faculty members in our department and others to, at a minimum, implement epistemically demanding practices in their courses, like developing hypotheses and analyzing data, which can be done in any classroom setting. We support Auchincloss et al.'s (2014) argument for curriculums having more CUREs for students to participate in. The more CUREs students have, the more likely it will be they will reach challenging outcomes, like having the ability to navigate uncertainty, obtaining a science identity, and persisting in science.

Limitations

Above all, this assessment of the CUREs in our course was valuable in directing us to the aspects of student attitudes of which we have influence, and in confirming the amount of time and effort it takes to improve student attitudes about science. We note that survey response rates were lower than the number of students enrolled in the course, 884, and response rate nearly halved across the surveys, most likely due to the increase in time constraints undergraduates experience across a semester. Yet, our lowest sample size, 30 post CURE 3 respondents, was on par with sample sizes seen in similar studies (e.g., 16 participants in Harrison et al., 2011). We acknowledge selection bias in our study. Selection biases are common in survey research, but they raise concerns that the retained students do not represent the overall population. In particular, ethnic diversity was absent in the last set of survey respondents, and more of these students were first-year students and were planning to attend graduate school than the respondents of the other three surveys.

We made all of our surveys anonymous to protect our students' identity and mitigate the threat of social bias, in which students respond a certain way because they are either implicitly or explicitly aware of the desired response (Bowman & Hill, 2011). We were not able to identify the influence the lab instructor or section had on attitudes. We decided not to assign pseudonyms to 884 students, in which case answers could have been matched to a student across surveys. By doing so, we may have mitigated the issue of testing fatigue and increased our sample size of unbiased students. We expect that if we tracked students across surveys and only used data from students who took all four surveys, samples sizes would have been considerably lower, and responses may have been biased towards the most diligent students. Instead, we relied on group means from unknown individuals, meaning that completed surveys at each point could have been from entirely different students. Here, we have a sample of our student population at each time point, and we account for this in our linear regression models.

We did not have a control group in which some BIOL 1615 lab sections did not experience the CUREs. Addressing the effect of CUREs vs. no CUREs on students has been addressed by others (e.g., Wenk, 2000; Indorf et al., 2019). Here we were interested in the differences in student science attitudes across our CUREs. We encourage researchers to use the CURE Survey science attitude items in other settings.

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