**JULIE DANGREMOND STANTON**

**Associate Professor of Cellular Biology**

**University of Georgia**

Nomination Portfolio for the University System of Georgia

Regents' Scholarship of Teaching and Learning Award

Fall 2020

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November 2, 2020

USG Regents' Scholarship of Teaching and Learning Award Committee
270 Washington Street SW
Atlanta, GA 30334

Dear Members of the Scholarship of Teaching and Learning Award Committee,

It is an honor to write this letter of support on behalf of Dr. Julie Stanton for the USG Regents' Scholarship of Teaching and Learning (SoTL) Award. Dr. Stanton is an Associate Professor in the Department of Cell Biology whose contributions to the SoTL landscape, along with her intentional integration of her research into her teaching and mentoring projects, make her highly deserving of this award.

Increasing student success in science—both in the classroom and beyond—is the driving force behind Dr. Stanton's teaching philosophy and SoTL research agenda. Dr. Stanton's research demonstrates that facilitating a student's development of metacognitive skills enables them to engage in deep conceptual learning, thereby increasing their academic and professional success. Using her research to inform her teaching, Dr. Stanton intentionally incorporates learning activities to help develop her students' metacognition, routinely encouraging upper division students to embrace the "desirable difficulty" of learning.

Dr. Stanton also is well-aware that effective group work helps students develop critical reasoning and problem-solving skills much more effectively than individual learning. Using the evidence-based pedagogy of Process Oriented Guided Inquiry Learning (POGIL), Dr. Stanton renovated UGA's Cell Biology course (CBIO 3400) so that students learn and apply conceptual knowledge while engaging in analysis of real data, designing actual experiments in small groups. The efficacy of POGIL for student learning and success led Dr. Stanton to begin asking research questions about social metacognition, emotions, and actions within a group. And so the cycle of SoTL continues, quite naturally for Dr. Stanton.

Dr. Stanton is a genuine leader in the scholarship of teaching and learning. She is a sincere advocate for the systematic study of student learning in a STEM environment and the immediate application of a study's findings to advance STEM education. To this end, Dr. Stanton has trained and mentored a variety of other instructors in the use of strategies to develop metacognition in undergraduate STEM majors and in the adoption of the POGIL curriculum. Furthermore, Dr. Stanton has published her POGIL problem sets and lesson plans in a peer-reviewed open-access journal, thus ensuring that other instructors can leverage her work to improve their own students' learning. In other words, she routinely uses her scholarship to impact both her own teaching and the teaching of others.

Dr. Stanton's national reputation as a leading SoTL scholar is evidenced by her success in securing research funding over the last 10 years, including a prestigious NSF CAREER Award of over $1,000,000. Her research has been published in key discipline-based educational research and SoTL journals, including an invitation from the editorial board of the journal *CBE-Life Sciences Education* to develop an online evidence-based guide for instructors based on her groundbreaking work on metacognition. Dr. Stanton is also an exceptional educator and mentor, recognized at both the college and University level through the 2018 Sandy Beaver Excellence in Teaching Award (2018), a nomination for the Franklin College Excellence in Undergraduate Teaching Award (2017), and selection as a Center for Teaching and Learning Lilly Teaching Fellow (2015-2017).

Dr. Stanton is exceptional in blending teaching and research to bring about positive change, which makes her highly deserving of the USG Regents' Scholarship of Teaching and Learning (SoTL) Award.

Sincerely,

S. Jack Hu
Senior Vice President for Academic Affairs and Provost

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Franklin College of Arts and Sciences
*Office of the Dean*

September 1, 2020

Regents' Scholarship of Teaching and Learning Award Committee
University System of Georgia
270 Washington Street, SW
Atlanta, GA 30334

Dear Selection Committee Members:

I am pleased to offer my strong support for Dr. Julie Stanton's nomination for the University System of Georgia Regents' Scholarship of Teaching and Learning Award. Dr. Stanton joined University of Georgia (UGA) in January 2014 as a tenure-track Assistant Professor of Cellular Biology, with a focus on biology education research. Based on her excellent record in teaching and research, she earned tenure and was promoted to Associate Professor in 2020. Dr. Stanton has built an innovative education research program that is focused on mechanisms to enhance learning and persistence of undergraduate science majors. Her lab has been awarded four NSF grants in the past seven years, including a prestigious NSF CAREER Award for her work on student metacognition. Since coming to UGA, Dr. Stanton has also built a reputation on campus as an outstanding teacher who cares deeply about students and uses evidence-based approaches to support their learning.

Dr. Stanton has been a leader in transforming undergraduate teaching in her department. Upon her arrival at UGA, she was tasked with developing a new approach for breakout sessions in CBIO3400 (Cell Biology). Cell Biology serves 600 students per year and is required course for six life science majors at UGA. To help students understand the experimental basis of major concepts in cell biology, Dr. Stanton developed a group of problem sets for Cell Biology breakout sessions based on an approach called "Process Oriented Guided Inquiry Learning" (POGIL). Using data from primary literature, Dr. Stanton created tiered exercises for small groups that enable students to apply cell biology concepts and analyze cell biology data. Student response to Dr. Stanton's new approach has been overwhelmingly positive. In particular, students comment that they value the opportunity to gain critical thinking skills and collaborate with other students through Cell Biology problem sets. On the faculty side, Dr. Stanton has trained 10 other Cell Biology instructors to adopt her POGIL problem sets and teach their own breakout sessions in SCALE-UP rooms. She has also published two papers on her problem sets in the peer-reviewed journal *CourseSource* so that faculty at other institutions can benefit from her work. Dr. Stanton's efforts in the classroom have been recognized with the Franklin College Sandy Beaver Excellence in Teaching Award and her selection as a National Academy of Sciences Teaching Fellow.

Dr. Stanton has widely disseminated her scholarship of teaching and learning during her seven years at UGA. She has shared her work through seven key publications in peer-reviewed journals such as *CBE-Life Sciences Education*, *International Journal of STEM Education, and Journal of Microbiology and Biology Education.* Her work on metacognition has received considerable attention. Dr. Stanton's 2015 *CBE-Life Science Education* paper on metacognition was selected by the Editorial Board for the annual highlights issue. In this paper, Dr. Stanton outlined the first model of metacognitive development in undergraduate biology students. This model is now being used by Dr. Stanton's lab and other labs (e.g., Sebesta, Speth, & Batzli, 2017; Sabel, Dauer, & Forbes, 2017) as a framework to guide current research on metacognition. Dr. Stanton's 2017 *CBE-Life Sciences Education* paper was selected as a featured article by the Editor-in-Chief. In this paper, Dr. Stanton provided the first in-depth examination of an important metacognitive skill in undergraduate biology students. She also revealed previously unknown barriers to students' use of metacognition. Based on her results, Dr. Stanton made suggestions for instructors to who want to help students anticipate and plan for barriers they may encounter while studying.

Dr. Stanton's national reputation in the scholarship of teaching and learning is also evidenced by her regular invitations to present her work. Since coming to UGA she has given 5 keynote addresses/plenary talks on her research in STEM education. For example, she gave the 2020 STEM Educators Lecture at Temple University and a plenary talk at the CIRCLE Integrating Cognitive Science with Innovative Teaching in STEM Disciplines Conference in 2018. She has also given 11 invited research seminars at universities such as University of California at Irvine, Purdue University, Iowa State University, and Washington University in St. Louis. Many of Dr. Stanton's seminar hosts have also asked her to give teaching workshops on their campuses so that she can share her knowledge with faculty who want to incorporate metacognition into their classes. In addition to these presentations, Dr. Stanton was invited by the Editorial Board of *CBE-Life Sciences Education* to develop an online evidence-based teaching guide on metacognition, which will help even more instructors give their students practice in using metacognitive skills.

Dr. Stanton is a local and national leader in promoting and supporting the scholarship of teaching and learning. For example, she is a founding member of the UGA Scientists Engaged in Education Research (SEER) Center and a current member of the SEER Center executive board. Dr. Stanton was also the Director and PI of an NSF-funded Research Experience for Undergraduates (REU) program on undergraduate biology education research (UBER). From 2014-2019 she led this 9-week summer program designed to engage undergraduates from across the country in research on teaching and learning in biology with mentorship from faculty at UGA. Nationally, Dr. Stanton has been recognized for her scholarship of teaching and learning expertise by the American Society for Microbiology (ASM). She served as an invited facilitator for two national ASM programs, the ASM Science Teaching Fellows program as well as the ASM Improving Undergraduate Biology Education Based on Research in Science Learning, which she also helped develop. Both programs help faculty apply well-established results from current education research to their own classrooms.

We are fortunate to have a faculty member like Dr. Julie Stanton who exemplifies excellence in the scholarship of teaching and learning. I give her my highest recommendation for the University System of Georgia Regents' Scholarship of Teaching and Learning Award.

Sincerely,

Michelle Momany, Ph.D.
Associate Dean for Life Sciences, Franklin College of Arts and Sciences
Professor of Plant Biology

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October 16, 2020

Dear Selection Committee Members,

I am delighted to write a letter of support for Dr. Julie Stanton's nomination for the University System of Georgia-Regents' Scholarship of Teaching and Learning (SoTL) Award. I actively engage in SoTL in the discipline of biology, and was fortunate to be given this award in 2019. I have observed Julie's teaching and reviewed her papers and grants. Julie is a leader in SoTL within UGA and nationally, and is at the forefront of her research areas. She exemplifies all of the criteria of the Regents' SoTL Award and I give her my strongest possible recommendation for this award.

Julie began engaging in SoTL before her faculty position at UGA. In a prior position, she aimed to improve the retention and success of students in a freshman biology course with historically high DWF rates. She observed that struggling students often lacked the ability to reflect on and improve their learning (i.e., to be metacognitive). Therefore, she developed a metacognition intervention to help students reflect on their exam performance and make plans to improve their approach to learning. The effect was positive, significantly lowering DWF rates, but Julie was unsatisfied with the improvement she saw in her students. She dug into the literature to better understand how students develop metacognitively so that she could expand her efforts. She soon recognized that existing literature was sparse and insufficient. Her scholarly interest piqued, Julie began building a SoTL research program to investigate metacognitive development in undergraduate life sciences majors.

Just seven years later, Julie is nationally known for her SoTL focused on metacognition and is sought after as a leading expert in this area. She has conducted research to generate a model of metacognitive regulation in biology students. This model is now considered foundational in the area; I have seen it used as a guiding model in other researcher's published papers, presentations at leading conferences, and grant proposals. Her subsequent work has continued to refine and expand this model of metacognitive regulation and our understanding of metacognitive development across an undergraduate career. It is truly impressive that even Julie's earliest SoTL contributions have defined the landscape of work in the area!

Julie's exceptional scholarship about metacognition has been nationally recognized in multiple ways. She has published multiple peer-reviewed articles related to metacognition, including three in the leading journal for SoTL in undergraduate biology, *CBE-Life Sciences Education*. Julie was also recently granted an NSF CAREER Award, a highly prestigious early-career award, to continue this work. Julie is regularly invited to give teaching workshops and research seminars related to metacognition. Critically, instructors commonly report that her work has transformed how they support their students' metacognitive development.

Julie also leads cutting-edge research that will ultimately contribute to the retention of students from groups historically underrepresented in STEM. She leads an NSF-funded project to investigate the unique strengths that Black and African American students bring to science majors. This work, which engages undergraduates as full co-researchers, has resulted in products such as workshop opportunities for UGA faculty to learn about implicit bias and the particular strengths of Black students. A key feature of this work—and one that is shaping future work in the field—is that it avoids a deficit perspective that undervalues what Black and African

American students bring to college courses. Her research is currently informing my own work with UGA faculty who are engaged in long-term teaching professional development. We are drawing on her results, and the expertise of her undergraduate co-researchers to create opportunities for faculty to learn about inclusive teaching. Julie has quickly risen to national prominence for her efforts to better understand how we can increase equity and diversity in science majors, as evidenced by her invitation to be a lead contributor for American Association of Colleges and Universities (AAC&U) efforts to broaden participation in STEM.

More locally, Julie has transformed a key capstone course for life sciences majors at UGA, including the sections taught by Julie and others. She fully re-designed this upper-division cellular biology course to integrate evidence-based teaching practices and to align with national calls from prominent organizations (e.g., American Association for the Advancement of Science (AAAS), the National Science Foundation (NSF)) about effective practices for teaching biology. In addition to using evidence-based strategies like writing to learn, metacognitive practice, and small-group problem solving in the lecture section of her course, Julie designed 16 lessons for a weekly 75-minute breakout section that accompanies the course. Each lesson guides students to work collaboratively to analyze data from the primary literature, helping students learn about important techniques in cell biology and providing repeated practice with scientific practices.

Julie disseminates her creative and evidence-based lessons beyond her own classroom. She has mentored other faculty to implement these lessons in their breakout sections, which represents a major shift from a historic lecture-heavy course. In addition, these lessons impact instructors nationally. Julie published two of these lessons in *CourseSource*, a peer-reviewed publication for evidence-based teaching resources. One lesson has already been downloaded 95 times, and the other has been downloaded 37 times in just four months! Julie is currently preparing other lessons for publication in collaboration with graduate students.

Julie is a local SoTL leader. She designed and led an NSF-funded summer research program for six years that engages undergraduates in SoTL in biology. This program is one of the most carefully crafted research experiences provided on the UGA campus and has trained over 45 undergraduates in SoTL. These undergraduates have gone on to become graduate students pursuing SoTL and K-12 educators. This program has given me the chance to mentor students who are now co-authors on papers. Julie is also a member of the executive committee of the Scientists Engaged in Education Research (SEER) center. A key mission of SEER is supporting SoTL scholars' development at UGA, and Julie's leadership will be paramount.

Julie epitomizes scholarly teaching and using research to fulfill and expand the instructional mission of the institution. Her SoTL impacts her students, students in other UGA biology courses, and students around the country. It also contributes to the scholarly knowledge base on which other research builds. We are fortunate to have Julie as a researcher and teacher at UGA. Personally, Julie is one of my most valued colleagues and I call on her regularly due to her SoTL expertise. I cannot imagine a better candidate for the Regents' SoTL Award.

Sincerely,

Tessa Andrews

Tessa C. Andrews, Associate Professor, Department of Genetics

## TEACHING PHILOSOPHY NARRATIVE

Throughout my education, I experienced the joy of engaging with outstanding science teachers who were dedicated to helping their students learn. Those teachers inspired me to become an educator and a scientist. In my first faculty position I found myself increasingly interested in understanding how students learn science. I decided to translate my passion for teaching into my research area because I wanted to have a meaningful impact not only on my own students, but on other faculty's students as well. My teaching and my scholarship of teaching and learning (SoTL) enhance one another, because the primary goal of both endeavors is to support undergraduate learning in science. Four main principles connect my teaching philosophy and SoTL.

***Principle One***: *Metacognition (awareness and control of one's own thinking) is a powerful mechanism for helping life science students learn*. When I taught Introductory Biology, I was alarmed by the percentage of students who did not pass the course. I was using active learning methods shown to improve achievement, but I wanted to do more to help my students learn. I knew from cognitive science that students with strong metacognitive skills are positioned to learn more, perform better, and persist longer than peers who have not yet developed their metacognition. I designed a SoTL study to test the effect of providing opportunities for metacognitive practice on exam performance in Introductory Biology. The results were statistically significant, but underwhelming, so I went back to the literature to learn why my intervention did not work as well as I hoped. I found that not much was known about how metacognition develops in undergraduates. Since then I've dedicated myself to studying undergraduate metacognitive development. My long-term goal is to use my results to help first-year students accelerate their metacognitive growth so they can learn more, perform better, and persist in the life sciences.

While I continue to study metacognition, I am already using the results of my research to inform my teaching. In one study, I learned that Introductory Biology students are willing to adjust their approaches to learning, but many need help understanding effective learning approaches in order to act on their metacognition (Stanton et al., 2015). As a result, I teach relevant learning approaches in my courses, such as the use of a concept map to organize related ideas. This allows students to learn not only *what* approaches exist and *how* to do them, but also *when* and *why* a particular approach is appropriate. In another study, I learned that some upper-division life science students avoid using effective learning approaches because they wish to avoid discomfort (Dye & Stanton, 2017). As a result, I now talk openly with students about "desirable difficulties" (Bjork & Bjork, 2011). I explain that it is normal to feel a bit uncomfortable when experiencing new challenges in our class, and that these experiences can enhance their learning. In another study, I learned that life science students have difficulty evaluating their study plans (Stanton et al., 2019). Most students rely solely on their performance to determine whether their plans were effective. To help my students metacognitively evaluate, I give them assignments that ask them how well their plans prepared them to make connections between concepts, apply information, or monitor their understanding.

***Principle Two:*** *Small-group work helps life science students learn how to think critically, solve problems, and communicate ideas.* These skills are important for students not only during college, but also in their future careers. In my courses, I use an evidence-based method called Process Oriented Guided Inquiry Learning (POGIL) to give students the practice required to develop complex skills (Moog et al., 2006). POGIL is an approach to small-group work that involves students collaborating in groups of three with each student having a defined role (manager, recorder, or presenter). POGIL encourages students to generate knowledge by exploring content, explaining ideas, and applying concepts, while developing process skills such as teamwork, communication, and problem solving. To help my students practice these skills, I created, tested, revised, and retested a suite of 16 POGIL lessons for my undergraduate Cell Biology course. In my POGIL lessons, students work with material drawn from current cell biology research to learn current methods, analyze real data, and design experiments. I have trained and mentored 10 faculty colleagues to use my POGIL lessons, and I have published two of my POGIL lessons in *CourseSource* (Stanton & Dye, 2017; Pfeifer & Stanton, 2020).

While observing my students engaged in POGIL lessons, I became curious about how students might help each other learn by stimulating metacognition in one another. This is social metacognition, which happens when students express their thoughts for evaluation by their peers and when students evaluate thoughts expressed by their peers (Van de Bogart et al., 2017). As I watched my students solve problems in small groups, I realized that many life science students have not received any training in the skills needed for effective collaboration. Thus my experiences in the classroom led me to ask two research questions: (1) What types of things do students say during small-group work that stimulates social metacognition in one another, and (2) What types of social metacognition lead to greater reasoning during problem solving? I am using my results to develop a program to train and cue students to use social metacognition in order to enhance collaborative problem solving.

***Principle Three:*** *Students from diverse backgrounds bring a wealth of strengths and abilities to science.* Early in my career I taught a research-based laboratory for first-year Introductory Biology students funded by the Howard Hughes Medical Institute. Instead of the traditional “cookbook” lab, students engaged in authentic research projects on bacteriophages, which are viruses that infect bacteria. While training students in microbiology and molecular biology techniques, I found that students from groups that are traditionally underrepresented in science often exceled at research. For example, when an experiment did not turn out as expected, they were able to think through potential problems and adjust their protocols, whereas other students let disappointment get in the way of their ability to troubleshoot effectively. My teaching experience has shown me the unique strengths and abilities that students of color and students with disabilities bring to science, and the importance of retaining these talented students in science majors. Thus part of my SoTL is devoted to promoting the persistence of students from minoritized groups and bringing awareness of their strengths and abilities to science faculty.

***Principle Four:*** *Undergraduate research is a highly effective form of experiential learning that gives students the opportunity to experience self-efficacy, autonomy, and a sense of belonging.* One of the greatest joys in my career is providing undergraduates with training and mentoring in research and seeing how they are able to build on that foundation to become confident and independent researchers. Since 2014 I have collaborated with 17 undergraduate researchers at UGA on SoTL projects. Ten undergraduate researchers from my lab have contributed to published and submitted papers as co-authors and they have presented our research in 20 talks at local, national, and international meetings. I have also helped train the next generation of SoTL researchers as PI and Director of Undergraduate Biology Education Research (UBER) Research Experience for Undergraduates (REU) program, funded by the National Science Foundation (NSF). In leading this program I aim to inspire future faculty to become outstanding science teachers and SoTL researchers who are dedicated to helping their students learn.

## IMPACT OF SCHOLARSHIP OF TEACHING AND LEARNING (SoTL)

My teaching philosophy and teaching experience inform my SoTL in three areas: (1) the development of metacognition in undergraduate life science students, (2) the strengths Black and African American students use to succeed in their science majors, and (3) the self-advocacy experiences of STEM majors with ADHD and/or specific learning disabilities (SLD). Each of these projects is supported by grants from the National Science Foundation (NSF). In all of my scholarship, my primary goal is to gain knowledge that will allow us to enhance learning and promote persistence of undergraduate science majors. I have taken an important leadership role in SoTL by directing an NSF-funded summer research program focused on teaching and learning in biology. In the sections that follow I describe my major findings in each area and the ways my research has impacted teaching and learning.

My national reputation in SoTL is demonstrated by my invitations to speak about my work and serve as a peer reviewer. Since joining the faculty at University of Georgia (UGA) in 2014, I have given five invited keynote addresses/plenary talks and 12 invited research seminars. I have served on multiple review panels for NSF in the Division of Undergraduate Education. I was a member of the editorial board of the *Journal of Microbiology and Biology Education* until 2018, and I serve as a reviewer for several education journals. My national reputation in SoTL is also evidenced by invitations to help lead national teaching and research programs for the American Society for Microbiology, give teaching workshops at other institutions, and represent UGA as a National Academy of Sciences Teaching Fellow.

### Differences in Metacognitive Regulation in Introductory Biology Students: When Prompts Are Not Enough

Metacognition is a powerful yet underused means of helping undergraduates succeed in life science majors. **Metacognition** is defined as awareness and control of thinking for the purpose of learning (Cross & Paris, 1988). Metacognition improves student achievement in college (Vukman & Licardo, 2009) and correlates positively with problem-solving ability (Sandi-Urena et al., 2012). Students with strong metacognitive skills can identify concepts they do not understand and select appropriate strategies for learning those concepts. They know how to implement selected strategies and carry out their overall study plans. They can evaluate their strategies and adjust their plans based on outcomes. ***Metacognitive skills are critical for learning in the life sciences, but many undergraduates have not yet developed these abilities.***

While prior research has characterized metacognition in K–12 students, there are gaps in our knowledge of metacognitive development in college students (Zohar & Barzilai, 2013). These gaps make it challenging to create effective interventions for supporting undergraduate metacognition. I have conducted some of the first in-depth studies aimed at understanding how undergraduate life science students develop metacognition. My primary goals are to (1) do foundational research that influences development of theory on metacognition, and (2) use my results to design research-based interventions to help first-year students accelerate their metacognitive growth.

I began by studying Introductory Biology students' use of metacognitive skills in the context of exam preparation (Stanton, Neider, Gallegos, & Clark, 2015). I developed open-ended exam self-evaluation assignments to collect metacognition data from undergraduates (n=245). In collaboration with a colleague from higher education, a graduate student, and an undergraduate student, I used content analysis to code the assignments for evidence of students' use of three key metacognitive regulation skills: monitoring, evaluating, and planning. I found that nearly all of the students were willing to select new learning strategies while making a study plan, but only half of the students could evaluate the effectiveness of strategies they used, and less than half planned for future exams based on their evaluations. Because effective metacognition involves taking action to learn (Sandi-Urena et al., 2011), I also explored whether students who could successfully evaluate their learning actually carried out their new plans. I found that half of these students failed to follow their plans. They explained this was because they did not need to change (because they thought they knew the material) or because they did not know how to carry out their plans. I concluded that prompting Introductory Biology students to use metacognition was enough for some students to take action to learn, but other students needed additional help in order to respond optimally.

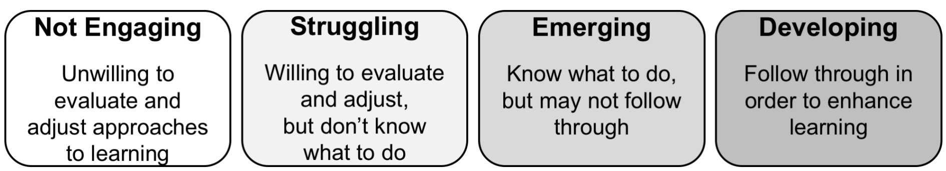


**Figure 1: Proposed categories in my model of metacognitive development in life science undergraduates.** The majority of the Introductory Biology students in my sample (n=245) fit *Struggling* and *Emerging* categories; few students were *Emerging* or *Developing* (Stanton et al., 2015). This model is not necessarily linear and a student's metacognition category may vary based on their learning context.

From these data, I proposed a continuum with categories of metacognitive development represented in my sample of 245 students (Figure 1). I described four potential categories: *Not Engaging*, *Struggling*, *Emerging*, and *Developing* (Table 1). The *Not Engaging* students did not evaluate their study plans, and were unwilling to change their learning strategies. Most of the students in my study belonged in the *Struggling* or *Emerging* categories. *Struggling* students were willing to change, but they had trouble evaluating and adjusting for the next exam. These students selected strategies that were not well aligned with issues they reported. Emerging students could evaluate and adjust for the next exam and they selected appropriate learning strategies, but they did not always follow their plans. *Developing* students were rare in my sample of Introductory Biology students. These students evaluated their study plans, adjusted them to enhance their learning, and followed their new plans.

**Impact:** I proposed the first model of metacognitive regulation development in undergraduate life science students. This model is now being used by my lab and other labs (e.g., Gray & Eisen, 2019; Heidbrink et al., 2020; Sabel, et al., 2017 2017; Sebesta & Speth, 2017) as a framework to guide current metacognition research. This study has important implications for teaching, which I have shared widely through peer-reviewed papers, invited seminars, invited workshops, and conference talks. First, instructors are often told to ask students reflective questions after an activity or assessment in order to encourage metacognition. My research suggests that although this approach can be helpful for some students, many first-year students may not be able to respond metacognitively to prompts. They need more help developing their metacognition before they can do so. Second, my research reveals that most Introductory Biology students recognize a need to change how they learn, but they need help understanding what learning strategies exist and how, when and why to use those strategies appropriately.

**Table 1: Details on proposed categories in my model of metacognitive development in life science undergraduates**

| **Metacognitive Category:** | **Not Engaging** | **Struggling** | **Emerging** | **Developing** |
|---|---|---|---|---|
| **Evaluating & Planning** | Did not evaluate plan for Exam 1 and did not use evaluation for when planning for Exam 2 | Evaluated plan for Exam 1, but did not use evaluation when for planning for Exam 2 | Evaluated plan for Exam 1 and used evaluation when for planning for Exam 2 | Evaluated plan for Exam 1 and used evaluation when for planning for Exam 2 |
| **Followed Study Plan** | *Did not change plan for Exam 2* | Some followed plan for Exam 2 | Some followed plan for Exam 2 | Followed plan for Exam 2 |
| **Metacognitive Challenge** | Recognizing need to use different study strategies | Selecting appropriate strategies | Carrying out appropriate strategies | *Not identified in Stanton et al., 2015* |
| **Example Quotes**<br><br>In response to why a new strategy would be helpful: | *"I am going to do the same things but work harder… because I apparently cannot figure out what you are asking.* | *"It is a different way for me to study and understand biology. It is out of the norm of the way I study so maybe it will help."* | *"Answering the questions in as much detail as possible will allow me to find the gaps in my knowledge and study accordingly."* | *"(The weekly questions) effectively enforce thinking of how concepts are tied together and how they apply to the real world."* |

Using data from exam self-evaluation assignments, I proposed four categories of metacognitive regulation. Each category is further described in Stanton et al., 2015.

**Metacognition in Upper-Division Biology Students: Awareness Does Not Always Lead to Control**

My study of Introductory Biology students (Stanton et al., 2015) led to several interesting questions for further investigation. For example, aside from a lack of time, why did *Emerging* students (Table 1) fail to follow their study plans? When, why, and how do *Developing* students (Table 1) use the metacognitive regulation skill of evaluation? I decided to answer these questions by studying senior-level life science students' use of one important metacognitive skill, evaluation (Dye & Stanton, 2017). **Evaluation** includes the ability to determine the effectiveness of individual learning strategies and appraise and adjust overall study plans. I examined students with well-developed metacognition to gain insights for helping other students improve their metacognitive skills. In collaboration with Kathryn Dye, a graduate student in my lab, I used data from post-exam self-evaluation assignments to purposefully sample upper-division biology students with high metacognitive regulation skills (n=25, from an initial population of n=126). Kathryn conducted semi-structured interviews and we used content analysis and pattern coding to identify themes in the interview data.

I found that students in our study did not evaluate in high school because they did well in their science classes without having to study. I also found that students evaluated their approaches to learning when their undergraduate science courses presented novel challenges. For example, in organic chemistry, students had to learn through non-math based problem solving for the first time. Most students evaluated in response to an unsatisfactory grade, but some evaluated when they monitored their understanding using study tools such as practice exams. I also gained an understanding of the barriers students face when they try to change their approaches to learning based on their evaluations. For example, a few students in my study continued to use ineffective study strategies even though they were aware of the ineffectiveness of those strategies. A desire to avoid feeling uncomfortable was the main reason they did not use strategies that they knew were effective for learning.

**Impact:** I provided the first in-depth examination of an important metacognitive regulation skill in life science undergraduates. I also uncovered previously unknown barriers to students' use of metacognition. I showed that students may be aware of effective strategies for learning, but they may not use them because those strategies cause them discomfort (e.g., because of increased cognitive effort to enact active strategies and stress of realizing knowledge gaps). I interpreted my findings using social cognitive theory and behavioral change research. *Based on my results I have shared several specific recommendations to instructors at UGA and instructors across the country*. Instructors should note that (1) many life science students come to college with little experience in evaluating their study approaches, (2) students can benefit from a mini-exam early in a course to encourage them to evaluate their approaches to learning, and (3) students can benefit from explicit discussion of the value of discomfort while learning.

**Knowledge of Learning Makes a Difference: A Comparison of Metacognition in Introductory and Senior-Level Biology Students**

Next I sought to directly compare introductory and senior-level life science students to gain insights into how their metacognition might develop over time (Stanton, Dye & Johnson, 2019). Specifically, I investigated students' ability to evaluate, as well as the reasoning behind their evaluations. Together with a graduate student and an undergraduate student, I coded student responses to post-exam self-evaluation assignments for evidence of evaluating (n=315). I found that introductory and senior students in my study did not differ in their ability to evaluate their individual strategies, but senior students were better at evaluating their overall plans (p-value<0.01). I examined students' reasoning and found that senior students use knowledge of how people learn to evaluate effective strategies, whereas introductory students consider how well a study resource matches the exam to determine its effectiveness. I also found that senior students consider modifying their use of a study strategy to improve its effectiveness, whereas introductory students abandon strategies they evaluate as ineffective. Both groups use performance to evaluate their plans, and many students use their feelings of confidence or preparedness as a proxy for metacognition.

**Impact:** Through this work I offered insights into how metacognition might develop in life science undergraduates. I identified key differences in the reasoning behind introductory and senior students' evaluations. I interpreted my findings and made suggestions for instructors in the context of research from cognitive science, which aligns with the NSF's emphasis on connecting work from cognitive science to education research. Based on this study, I called for caution in using cross-sectional research designs, and I highlighted the need to consider the effects of learning context on metacognition. These findings have not only affected my teaching, but they have also influenced others' teaching. For example, this research has raised instructor awareness that (1) introductory students may need help learning different ways to enact a strategy, and (2) students may need help evaluating their study plans based on criteria other than their performance or feelings. Through invited workshops I've shown instructors how to provide direct instruction for students on how to enact a strategy. I've also encouraged instructors to provide students with questions to evaluate their study plans such as: "*How well did your plan help you apply concepts and make connections between ideas?*"

As a result of this work, I was invited by the editorial board of *CBE-Life Science Education* to create an online evidence-based teaching guide for instructors who want to support their student metacognition. I am collaborating on this interdisciplinary project with Dr. John Dunlosky, an expert in cognitive science who studies metacognition. Our metacognition guide will distill key findings from the literature to provide instructors with research-based methods they can readily implement in their own courses.

**Ongoing Scholarship on Metacognitive Development and Social Metacognition**

In 2020, my metacognition scholarship was recognized with an NSF CAREER Award, which will allow me to continue this research. I will conduct the first longitudinal study of undergraduate metacognitive development across multiple institutions. I will investigate student metacognition in three different contexts: a doctoral university, a master's university, and a college that primarily awards associate's degrees. This research will test and refine my model of metacognitive development (Table 1).

I am also interested in how instructors can help students learn through collaboration. While working in small groups, students can stimulate metacognition in one another, leading to improved learning outcomes (e.g., Hadwin et al., 2011). This entails **social metacognition**, which is when students express their thoughts for evaluation by their peers and when students evaluate thoughts expressed by their peers. Social metacognition can contribute to successful collaboration, but students and instructors need guidance on the types of metacognitive statements and questions (utterances) that are effective. I am currently investigating the types of metacognitive utterances that increase reasoning in the context of small-group problem solving in a life science classroom. I will use the results to test the hypothesis that training and cueing students to use empirically identified metacognitive utterances leads to higher quality reasoning.

**Supporting Self-Advocacy of STEM Majors with Disabilities**

I am committed to promoting the success of students with attention-deficit/hyperactivity disorder (ADHD) and/or specific learning disabilities (SLD) in undergraduate STEM courses. Although many students with ADHD/SLD are initially interested in obtaining undergraduate STEM degrees, their attrition from STEM majors is much higher than for students without disabilities. Students with ADHD/SLD face many barriers to accessing an undergraduate degree. One barrier arises at the start of college because of a shift in the legislation that guides the accommodation process. In high school, teachers and staff are responsible for identifying and accommodating students with ADHD/SLD. In college, students with ADHD/SLD are solely responsible for self-identifying and registering with a campus disability resource center (DRC) to receive “reasonable” accommodations. If their accommodations are not effective, the onus is on students with ADHD/SLD to initiate communication with DRC staff and often their instructors in order to adjust their accommodations. ***Self-advocacy skills have been linked to the success of undergraduates with ADHD/SLD, but little is known about how students with disabilities actually practice self-advocacy.***

I investigate the self-advocacy experiences of undergraduate STEM majors with ADHD/SLD with the goal of using the knowledge gained to help students with disabilities develop self-advocacy skills at the start of their college career. This project is supported by a prestigious NSF Graduate Research Fellowship awarded to a graduate student in my lab, Mariel Pfeifer. As a first step, we asked whether or not an existing conceptual framework of self-advocacy could fit with the experiences of undergraduate STEM majors with ADHD/SLD. The original conceptual framework proposed four components of self-advocacy for people with disabilities: knowledge of self, knowledge of rights, communication, and leadership (Figure 2) (Test et al., 2005), but this model had never been tested in undergraduate STEM majors. We designed semi-structured interview questions that would allow us to (1) determine the extent to which the four components of self-advocacy were used by undergraduate STEM majors with ADHD/SLD, and (2) identify new components of self-advocacy used by these students. Mariel conducted research interviews with 25 participants with SLD/ADHD who are STEM majors. We analyzed the data in collaboration with one or more undergraduate researchers who are also STEM majors with SLD/ADHD.

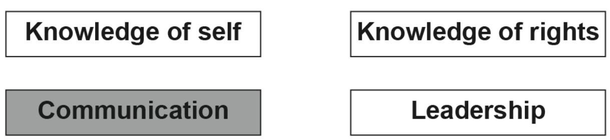


**Figure 2: Original conceptual framework of self-advocacy** outlined in Test et al., 2005. Communication is shaded because it is considered essential.

We found that self-advocacy for STEM majors with SLD/ADHD was much more complex than the original model suggested (Figure 3) (Pfeifer, Reiter, Hendrickson & Stanton, 2020). The original model of self-advocacy includes knowledge of self and knowledge of rights. Knowledge of self is knowing your own strengths and weaknesses as a student with a disability, and knowledge of rights is awareness of federal laws that guide the accommodation process. Besides knowledge of self and knowledge of rights, we found that self-advocacy for STEM majors involves novel forms of knowledge, such as knowledge of STEM learning contexts and knowledge of accommodations. For example, STEM majors using accommodations need to know that they can always request accommodations in any part of a STEM course whether that is the lecture, lab, or discussion section. We found that knowledge of accommodations, which involves knowing what accommodations exist and how they can be used to support their learning, allowed students to self-advocate for specific accommodations as needed to meet new challenges in their STEM courses. We also identified a novel self-advocacy behavior, called "filling gaps". Filling gaps involved students taking action to mitigate a limitation in either their formal DRC accommodations or a limitation in the instructional practices used in a STEM course. We also identified important beliefs, such as view of disability and agency, which influenced the self-advocacy of our participants.

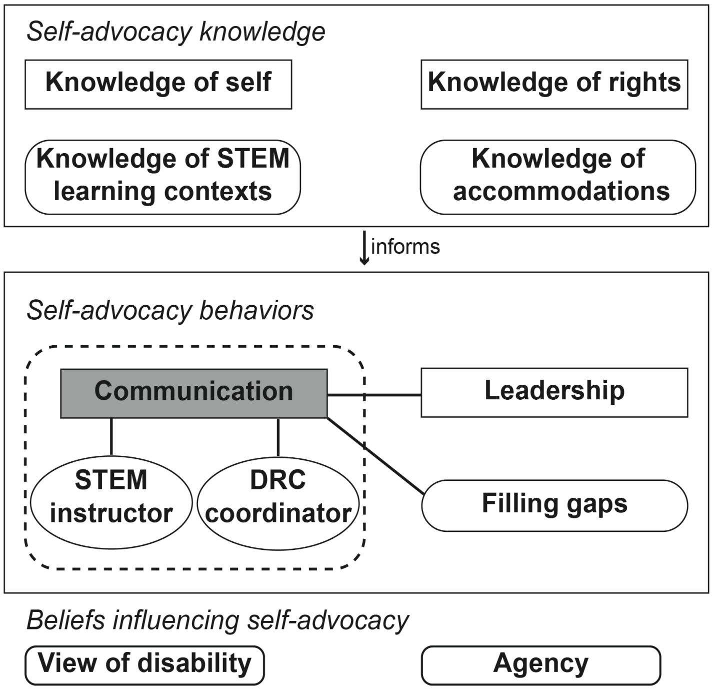


**Figure 3: Our model of self-advocacy for STEM majors with ADHD and/or specific learning disabilities (SLD).** Through analysis of data from STEM majors with ADHD/SLD we characterized the knowledge, behaviors, and beliefs that contribute to their self-advocacy. Rounded-edged boxes represent new components of self-advocacy uncovered in our study. Each component is described in detail and illustrated with participant data in our paper (Pfeifer, Reiter, Hendrickson, & Stanton, 2020).

**Impact:** Our model of self-advocacy now serves as a guide for promoting self-advocacy in undergraduate STEM courses. We have used the results of this research to inform STEM instructors and DRC staff about self-advocacy issues facing STEM majors with ADHD/SLD. For example, we have shared recommendations based on our data with STEM instructors through talks at national meetings and through a seminar we designed for DRC staff at University of Georgia. We have also used our model to characterize supports and barriers to self-advocacy in STEM (Pfeifer, Reiter, Cordero, & Stanton, *submitted for peer review*). Based on our findings, we provide instructors with specific recommendations for supporting students with ADHD/SLD in their courses. For example, we discourage instructors from making general statements about the time a student "should take" to complete an exercise because this can act as a barrier for students with an SLD that affects processing speed (e.g., dyslexia).

In the future, we will use the knowledge gained from this scholarship to develop and validate a survey measure of self-advocacy in undergraduates with ADHD/SLD. This measure will allow DRC staff across the country to identify students who might need assistance developing self-advocacy skills. Then DRC staff can help these students to practice using self-advocacy. A measure of self-advocacy will also enable quantitative studies of this construct, which are currently not possible given the lack of appropriate tools. Ultimately, this research will help support the success of undergraduates with ADHD/SLD, and reduce their attrition from STEM majors.

**Strengths that Black Undergraduates Use to Succeed in their Science Majors**

In collaboration with my co-PI, Dr. Darris Means, I investigate the strengths of academically successful Black[1] undergraduate science majors. Black students persist in undergraduate science degree programs at a rate that is lower than all other racial and ethnic groups. Many of the challenges that Black students face have been well characterized, but a major shortcoming of prior research is a lack of focus on the strengths Black students use to persist in science. ***To support Black students in earning undergraduate science degrees, we must understand their mechanisms of success.*** Investigating success requires new approaches. One way to do this is to focus on the many assets that academically successful Black science majors possess rather than their perceived deficits. Then we can use the knowledge we gain to not only support Black science majors' persistence, but also to raise faculty awareness of their success.

We are studying the community cultural wealth that Black undergraduate students bring to their science majors. The **community cultural wealth** framework consists of capital or "knowledge, skills, abilities, and contacts" that students of color possess and can use for educational success (Yosso, 2005, p. 69). We are using a novel approach called **participatory action research (PAR)** in acknowledgment of Black undergraduate students' critical expertise about their own persistence in science majors. In PAR, students are not simply research assistants, they are co-researchers who lead foundational research efforts. These same co-researchers then direct the translation of the research into programs that apply the knowledge for a wider audience, with the goal of promoting equity. I am one of the first biology education researchers to use PAR in my studies of undergraduates.

The objectives of this PAR study are (1) to investigate the community cultural wealth used by Black science majors, and (2) to develop research-based products for raising faculty awareness of Black students' community cultural wealth. Co-researchers have collected data at three different institutions using in-depth research interviews and photo-elicitation, a method for enriching interviews by discussing photos taken by participants. We are analyzing the data using inductive and deductive approaches to characterize the capital that Black undergraduates use to succeed in science majors.

**Impact:** Our PAR team is translating the results of our scholarship into products for raising faculty awareness of Black students' community cultural wealth and the ways science will benefit from Black students' persistence to science-related careers. For example, I have mentored co-researchers to create a student-designed, student-led workshop to address issues of equity and increase faculty knowledge of Black students' community cultural wealth. The co-researchers have given their interactive workshop for UGA faculty and they are currently developing an online version to be widely shared with faculty across the country. We have presented this work in an invited keynote address for the American Society for Cell Biology regional meeting and at national and international research meetings. In addition to promoting equity, this work will provide the knowledge base for developing quantitative measures to test hypotheses regarding Black students' community cultural wealth. This study will also advance the field by providing insights on the potential use of PAR for studying and addressing important issues in undergraduate STEM education.

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[1] Black is used describe individuals from the African diaspora, which also includes individuals who identify as African American.

**Leadership in Training the Next Generation of SoTL Researchers**

I am also dedicated to training the next generation of biology education researchers through my leadership of an NSF-funded Research Experience for Undergraduates (REU), known as the Undergraduate Biology Education Research (UBER) Program. I served as Director and PI of the grant from 2014–2019. This nine-week summer research program engages students (known as UBER fellows) in research on undergraduate biology teaching and learning with mentorship from UGA faculty. I led the recruitment and selection of UBER fellows and organized a professional development series on education research methods, a weekly journal club to discuss published papers, and panel discussions on graduate school and careers related to education research. While I was Director, 46 students from institutions all over the United States were trained in the UBER REU. Following their engagement in the program, UBER fellows reported great gains on a widely used instrument designed to measure learning during undergraduate research experiences (Table 2).

**Impact:** Under my leadership, UBER REU met its goals of (1) encouraging and preparing undergraduates to pursue graduate study in biology teaching and learning, (2) expanding the diversity of the talent pool in biology education research, and (3) contributing to the body of knowledge in undergraduate biology education. More than 80% of past UBER fellows reported an increased interest in pursuing a Ph.D. in science or education research after participating in UBER. Over 50% of UBER fellows are from groups that are traditionally underrepresented in science. UBER fellows have been co-authors on over 60 presentations at local, regional, national, and international meetings. Seven UBER fellows are co-authors on peer-reviewed papers (Andrews et al., 2019; Brickman et al., 2016; Limeri, et al., 2019; Limeri, et al., 2020a; Limeri, et al., 2020b; Pfeifer et al., 2020; Stephens et al., 2017) and one UBER fellow* is a co-first author on a peer-reviewed paper (Osueke*, Mekonnen, & Stanton, 2018). Another UBER fellow, Trevor Tuma, was awarded a prestigious NSF Graduate Research Fellowship for his biology education research. The impact of the UBER REU is expected to be exponential in the future, as UBER fellows become biology instructors and SoTL researchers who will apply what they have learned from this program in their future careers.

**Table 2: UBER Fellows' Reported Learning Gains on the URSSA**

| **Item** | **Mean** | **Standard Deviation** |
|---|---|---|
| *Analyzing data for patterns* | 4.6 | 0.5 |
| *Identifying limitations of research methods and designs* | 4.6 | 0.5 |
| *Understanding the relevance of research to the teaching and learning of science* | 4.6 | 0.7 |
| *Knowledge of how to do education research* | 5.0 | 0 |
| *Knowledge about the theories and frameworks that guide education research* | 4.7 | 0.7 |
| *Confidence in ability to contribute to science* | 4.7 | 0.7 |
| *Confidence in ability to do well in future science courses* | 4.9 | 0.4 |

The Undergraduate Research Student Self-Assessment (URSSA) is an instrument recommended by NSF for measuring student learning gains from research experiences. The items are rated on a 5-point Likert scale that ranges from no gains=1 to great gain=5.

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## EDUCATION

**Ph.D.,** Cellular Biology (2003)
*Department of Cellular Biology, University of Georgia, Athens, GA*
**B.S.,** Biology, Magna Cum Laude (1996)
*Division of Science, Truman State University, Kirksville, MO*

## PROFESSIONAL APPOINTMENTS

**Assistant Professor** (January 2014-2020); **Associate Professor** (2020-present)
*Department of Cellular Biology, University of Georgia (UGA), Athens, Georgia*
**Clinical Assistant Professor** (non-tenure track) (2008-December 2013)
*School of Molecular Biosciences, Washington State University, Pullman, WA*
**Postdoctoral Research Associate** (2005-2008)
*School of Molecular Biosciences, Washington State University, Pullman, WA*
**Visiting Assistant Professor of Biology** (2003-2005)
*Biology Department, Whitman College, Walla Walla, WA*

## SELECTED AWARDS AND RECOGNITIONS

- Recipient of the Sandy Beaver Excellence in Teaching Award, UGA (2018)
- Facilitator for American Society for Microbiology (ASM) Improving Undergraduate Biology Education Based on Research in Science Learning Program (2018-2019)
- Invited “Thought Leader” for American Association of Colleges and Universities Accelerating STEM Higher Education Reform and Broadening Participation (2018)
- Facilitator for ASM Science Teaching Fellows Program (2016-2018)
- Lilly Teaching Fellow, Center for Teaching and Learning, UGA (2015-2017)
- Paper selected by the Editorial Board as a featured paper in *CBE-Life Sciences Education*, American Society of Cell Biology (2015, 2017)
- Teaching Academy Fellow, UGA (2014-2015)
- Recipient of ASM Biology Scholars Alumni Research Fellowship (2014)
- National Academy of Sciences Life Science Education Fellow (2014)

## SELECTED SoTL PUBLICATIONS

- Pfeifer, M. A.[G], Reiter, E. M.[UG], Hendrickson, M.[UG], **Stanton, J.D.*** Speaking up: A model of self-advocacy for STEM undergraduates with ADHD and/or specific learning disabilities. *International Journal of STEM Education*. (2020) *7*(1), 1-21.
- Pfeifer, M.A.[G], **Stanton, J.D.*** Necessary and Sufficient? Solving the Mystery of the Mitochondrial Pyruvate Transporter. *CourseSource*. (2020) https://doi.org/10.24918/cs.2020.11

**corresponding author, [G]graduate co-author, [UG]undergraduate co-author*

- **Stanton, J.D.***, Dye, K.M.[G], Johnson, M.[UG] (2019) Knowledge of learning makes a difference: a comparison of metacognition in introductory and senior-level biology students. *CBE-Life Sciences Education*. *18*(2), ar24.
- Osueke, B.[UG], Mekonnen, B.[UG], **Stanton, J.D.*** (2018) How undergraduate science students use learning objectives to study. *Journal of Microbiology & Biology Education. 19*(2).
- **Stanton, J.D.***, Dye, K.M.[G]. (2017) Investigating the Function of a Transport Protein: Where is ABCB6 Located in Human Cells? *CourseSource*. https://doi.org/10.24918/cs.2017.19
- Dye, K. M.[G] & **Stanton, J.D.*** (2017) Metacognition in upper-division biology students: awareness does not always lead to control, *CBE-Life Sciences Education*. *16*(2), ar31.
- **Stanton, J.D.***, Neider, X.N., Gallegos, I.J.[G], Clark, N.C.[UG]. (2015) Differences in metacognitive regulation in introductory biology students: when prompts are not enough. *CBE-Life Sciences Education*. *14*(2), 1-12.
- **Stanton, J. D.*** (2013) "A poster-session review to reinforce course concepts and improve scientific communication skills". *Journal of Microbiology and Biology Education.* 14, (1), 116-117.

**SELECTED SoTL GRANTS; Total as Principle Investigator (PI) = $1,937,628**

- **Stanton, J.D. (PI).** National Science Foundation (NSF) Faculty Early Career Development Program CAREER Award Grant, #1942318, (2020-2025), $1,096,921. *"CAREER: Characterizing the development of metacognitive skills in life science undergraduates and how they use metacognition to learn independently and collaboratively".*
- **Stanton, J.D. (PI),** D. Means (Co-PI). NSF Improving Undergraduate STEM Education Grant, #1831153, (2018-2021), $299,958. *"Identifying the Community Cultural Wealth of successful Black science students through participatory action research"*.
- **Stanton, J.D. (PI),** Pfeifer, M. (Co-PI), Adair, S. (Co-PI). UGA Student Affairs Faculty Research Grant, (2018-2019), $4,500. *"Characterizing the self-advocacy experiences of students with learning disabilities/ADHD in undergraduate STEM courses".*
- **Stanton, J.D. (PI)** and Julie Luft (Co-PI). NSF Research Experience for Undergraduates Grant, #1659423, (2017-2020), $259,170. *"Undergraduate Biology Education Research (UBER) Program Version 2".*
- **Stanton, J.D. (PI).** UGA Office of the Vice President for Research Grant, (2017-2018), $8,919. *"Characterizing the strengths of academically successful Black science students".*
- **Stanton, J.D. (PI).** UGA Office of STEM Education Initiative Small Grant, (2015-2016), $7,924. *"Uncovering key transitions in undergraduate metacognitive development to enhance learning in biology".*
- **Stanton, J.D. (PI)** and Barbara Crawford (Co-PI). NSF Research Experience for Undergraduates Grant, #1262715, (2013-2017), $260,236. *"Undergraduate Biology Education Research (UBER) Program"*.

## INVITED KEYNOTE AND PLENARY TALKS on SoTL

- *Keynote address,* Annual STEM Educators Lecture, Temple University, Center for the Advancement of Teaching, Philadelphia, PA (2020).
- *Keynote address,* American Society for Cell Biology Regional Educators Meeting, Athens, GA (2019).
- *Plenary talk*, CIRCLE Integrating Cognitive Science with Innovative Teaching in STEM Disciplines Conference, St. Louis, MO (2018).
- *Plenary talk,* Society for Advancement of Biology Education Research, Minneapolis, MN (2017).
- *Keynote address*, Vision and Change Midwest/Great Plains Conference, St. Louis, MO (2014).

## SELECTED INVITED SoTL SEMINARS on Undergraduate Metacognitive Development

- University Alabama at Birmingham, Research on STEM Education Seminar (2020)
- University of California at Irvine, Education Research Initiative Seminar (2019)
- University of Northern Illinois, Biology Department Seminar (2019)
- University of North Georgia, Department of Biology Seminar (2017)
- Purdue University, Department of Biology Seminar (2017)
- Georgia Institute of Technology, School of Biological Sciences Seminar (2017)
- Washington State University, School of Molecular Biosciences Seminar (2017)
- Washington University in St. Louis, Biology Department Seminar (2016)
- Iowa State University, Genetics, Development, & Cell Biology Seminar (2016)
- Truman State University, Biology Department Seminar (2015)

## SELECTED SoTL WORKSHOPS and PRESENTATIONS

- *Invited workshop,* "Including Metacognition in Our Courses", University of California, Irvine, CA (2020)
- *Invited workshop,* "Including Metacognition in Our Courses", American Society for Cell Biology Regional Educators Meeting, Athens, GA (2019)
- *Invited webinar*, American Society for Microbiology (ASM) "Improving Undergraduate Biology Education Based on Research in Science Learning" (2018)
- *Invited workshop,* "Helping Students Learning Through Self-Evaluation", Washington State University Teaching Academy, Pullman, WA (2017)
- *Invited talk,* "Evidence-Based Teaching: Group Problem Sets in Cell Biology", Division of Biological Sciences, UGA, Athens, GA (2017)
- *Invited webinar*, " How People Learn", ASM Science Teaching Fellows Program (2016, 2017, 2018)
- *Invited workshop*, "Including Metacognition in Our Courses: Helping Students Learn through Self-Regulation", Innovations in Undergraduate Education Workshop Series, The Teaching Center, Washington University, St. Louis, MO (2016)
- *Peer-reviewed short talks,* American Education Research Association (AERA) Annual Meeting (2016, 2019)
- *Peer-reviewed short talks,* Society for the Advancement of Biology Education Research (SABER) National Meeting (2014, 2015, 2016, 2018, 2019, 2020)