MINI-REVIEW  
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Implementing inclusive practices in an active learning STEM classroom

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Johnson KMS. Implementing inclusive practices in an active learning STEM classroom. Adv Physiol Educ 43: 207–210, 2019; doi:10.1152/advan.00045.2019.—What do you bring to a conversation about diversity, equity, and inclusion? While acknowledging this conversation is important, many science, technology, engineering, and math (STEM) faculty shy away from engaging these topics. STEM educators often hesitate to participate in these discussions due to their self-perceived lack of knowledge or training. However, as institutions welcome ever-diversifying student populations, STEM faculty must consider how their teaching and mentoring approaches affect their students. During the 2018 American Physiological Society (APS) Institute for Teaching and Learning, STEM faculty and administrators engaged in conversations to better understand how their own approaches to diversity, equity, and inclusion affect the success of their students. During my plenary workshop, “Inclusive Practices for Diverse Student Populations,” participants investigated their own perspectives and practices. They also discussed approaches to implementing inclusive practices that complement active pedagogical best practices. In an attempt to replicate this workshop environment, I ask you to engage with an interactive set of exercises to investigate your own perspective on the topics of diversity, inclusion, and equity. After you consider your own approaches to these topics, I provide practical examples of inclusive practices that align or enhance active learning pedagogy. By building confidence, providing support, and promoting various pathways to success, inclusive practices enhance student learning and decrease social disparities in STEM education, ultimately supporting STEM innovation.

best practices in teaching STEM; diversity; equity; inclusion

Setting Expectations

As the attendees of my plenary workshop, “Inclusive Practices for Diverse Student Populations,” at the 2018 American Physiological Society (APS) Institute for Teaching and Learning (8) discovered, you are going to be an active participant in this interaction. Sometimes it is difficult to do something new or perceive yourself in a new way. Therefore, this active engagement might be a bit uncomfortable. That is all right, if not expected.

Why am I asking you to engage in this way? If you are reading this, you are probably familiar with the benefits of active learning techniques and the vast amount of evidence supporting its effectiveness (7, 16). Therefore, as instructors and administrators, we should employ the same proven techniques for our own learning. In addition, the daily tasks of our work often overshadow opportunities to examine and reflect on our teaching and mentoring. In this essay, I encourage you to take a few minutes to think, reflect, and handwrite your responses to prompts that provide you just such an opportunity. So, before we begin, grab some paper and a writing utensil. Please, during these exercises, be as honest with yourself as possible. Write down your gut reactions. If you feel yourself hesitate, or question your responses, you should still write them down. Remember, only you will see your answers.

What Do You Bring to the Conversation?

Classrooms and research groups are becoming more diverse (17). Diversity, equity, and inclusion are topics of discussion and action on campuses across the country.

Reflective Writing 1: What do you think when you hear the words diversity, equity, and inclusion? Take as long as you would like. Write down your honest feelings.

Before we go any further, we should define key words in this conversation. Diversity is the presence of various perspectives and experiences within a group, while equity is the availability of various pathways for different individuals to take to be successful. Inclusion is when individuals in a diverse group realize success using equitable pathways (Johnson KMS, Briggs A, Hawn C, Mantina N, Woods BC, unpublished observations). Success in science, technology, engineering, and math (STEM) has been defined as preparing students for their next academic or professional endeavor, while maintaining their enthusiasm about the content and skills (1). However, this definition is not universal among faculty (3). Some also argue success in STEM must include an understanding of the sociocultural implications of the work done by STEM academics and professionals, with the knowledge that scientific inquiry is not performed in isolation (27). In the context of this essay, success in STEM equates to students who use their strengths to make learning gains in a variety of STEM and social skills, while becoming or remaining enthusiastic and engaged about the science and the implications of their work.

Reflective Writing 2: Go back to your responses to the “Reflective Writing 1” prompt. What was easy or difficult about writing this first response? What patterns do you notice in your responses? How does your background or training influence what you wrote? Once again, take your time and be honest with yourself as you handwrite your answers.

There was a time in my life when considering diversity, equity, and inclusion would have made me uncomfortable or, at the very least, dismissive. I knew the “correct” answer was to acknowledge the importance of these concepts, but I was inclined to leave this discussion to the social scientists (11). As a physiologist, I could not see how my experiences, training, or
teaching had anything to do with issues of diversity, equity, and inclusion.

I often have conversations with other STEM professionals who are uncomfortable with their ability to address these issues, claiming they have no training. It is true that many STEM faculty have not encountered formal training. However, as instructors, especially those implementing inquiry-based practices, we often ask students to engage unfamiliar material or unpracticed ways of thinking (19). I ask, once again, that we hold ourselves to the same standards we demand of our students. Everyone has lived experiences and knowledge that informs their words, actions, and decisions. Therefore, everyone has something to contribute to a conversation about how differences in experience and knowledge influence our perspective.

Reflective Writing 3: List the knowledge, skills, and experiences you bring to a conversation about diversity, equity, and inclusion. State the obvious and the not so obvious, including transformative experiences and stories. Make sure to include aspects of how you categorize yourself, including race, ethnicity, expertise, profession, position, and hobbies. Can you think of instances when these classifications were prominent or possibly altered a conversation or interaction?

During any conversation regarding diversity, equity, and inclusion, I bring my formal doctoral and professional training as a physicist. While this might not seem relevant for these topics, in actuality, my scientific training influences how I interpret and analyze information. Therefore, it informs my perspective of inclusion. For example, my introduction to science, as early as elementary school, focused on learning facts. Answers were either right or wrong. In retrospect, this aspect of science was attractive and comforting; I always knew exactly where I stood and how to get a better grade. I am thankful for many wonderful teachers and mentors who expanded my understanding of science to include creative and expansive models of knowledge production. Nonetheless, I must acknowledge this binary of right and wrong is part of my training and the history of my discipline.

I also come to these conversations as a white woman who has experienced both increased support and detrimental treatment due to my race and sex. I must be vigilant that my approaches to inclusion are equitable to others, not just individuals like me. I do this through many ongoing collaborations, bringing diverse experiences and perspectives. Therefore, my professional and personal network informs my ideas. As an educator, I often hone my perspective through teaching and learning. All of these aspects, in addition to many more not listed here, influence the lens through which I examine diversity, equity, and inclusion.

As STEM educators, we bring our perspectives to our daily instructor-student interactions. This is particularly important to recognize and understand as we educate students who navigate a different academic trajectory than our own. Therefore, this critical examination of what informs our approach to inclusion is essential to understand how we can promote the success of our students.

Reflective Writing 4: What have I asked you to do during your “participation” in this article? Why? I often ask my students this question. Why are we doing what we are doing today? As I mentioned previously, during active learning, we are often too busy doing the prescribed activity to question why we are doing it.

Self-reflection on personal approaches to diversity, equity, and inclusion is an effective mode of exploring these topics (14, 26). Unfortunately, this particular format lacks the advantage of interactive feedback, but I encourage you to initiate and engage discussions with your colleagues and professional network to continue the conversation.

Inclusive Practices for the Classroom

Theoretical and personal perspective are foundational to the implementation of successful classroom practices. This very basic introduction is far from exhaustive, but it provides a starting point to begin experimenting with practical teaching applications.

Inclusive classroom practices promote and support the success of a diverse population of students as they navigate various, yet equitable, paths. My approach to these practices targets student experience and classroom methods that influence that experience. If students do not feel like they belong, are understood, or accepted, they will leave (23, 24); or, at the very least, they will not succeed (4, 13). Inclusive practices actively promote the narrative that all students accepted to the institution belong and are able to thrive at the institution.

Inclusive practice: embrace an asset-based approach. When I asked you to consider what you bring to conversations about diversity, equity, and inclusion, my objective was to shift your thinking from a deficit-based approach to an asset-based approach. A deficit-based approach focuses on what is missing to attain a goal or solve a problem, but an asset-based approach asks stakeholders to determine what strengths each individual or group brings to the problem (6, 15). These strengths are then leveraged to attain the desired outcome (10, 14). While originally implemented as a tool for community development, asset-based approaches are considered critical to inclusive success in the classroom (26). Therefore, as a STEM educator, your assets are your own experiences, knowledge, and skills. Once you recognize what you bring to the conversation, you can develop and use your assets to increase the success of your students.

Engage an asset-based approach with your students. For example, ask the class to make a list of the skills necessary to become a successful scientist. It is likely that this list will include the following: persistence, teamwork, patience, ability to learn from constructive criticism and failure, organization, creativity, and communication skills. While content knowledge will probably appear in this list, the majority of the items have very little to do with what scientists know, but rather what they can do. Have students consider which of their own “assets” they see on this list. Ask them to describe specific examples of when they demonstrated that asset. Students can then explain how they are going to leverage their assets to be successful in your course. Emphasize that differences in assets among students inherently provide different pathways to success, and that they should, therefore, expect that members of the class will achieve success in different ways.

Describe how your pedagogy will require similar or alternative skills. For example, will the final grade be a combination of scores for class contributions, presentations, writing assignments, group assignments, problem sets, and exams? It takes different skills to be successful in each of these types of activities, and, therefore, different students may excel in different aspects of the course. It is important to publicly state that your course will require these different skills, and that each student in the class brings a different
combination of skills that they should rely on to be successful. This explicit declaration is critical, because some students tend to gravitate toward group members or laboratory partners with skill sets similar to their own. This means that very talented students can be overlooked, the potential for successful collaborations is missed, and productivity or innovation is lost. If you notice that some students are not participating or are being pushed to the side during group work, ask the groups if they are taking full advantage of all of the assets in their group. Students, especially undergraduates, may not realize that embracing equitably pathways will actually enhance their own performance and learning.

**Inclusive practice: state expectations explicitly.** Students should know what you are asking of them. If you expect them to participate, they should know. Many evidence-based teaching practices are reliant on exploration and discovery (9, 19), which inherently involve some confusion and searching for answers. Let your students know that they should be feeling uncomfortable or confused with an activity. Students must know to expect discomfort. Otherwise, they may blame their confusion on their own perceived inabilities or deficiencies. This may lead to frustration, which can be counterproductive to student success and retention.

Inclusive learning is dependent on communication clarifying the various ways students might leverage their assets to find success. The pathways to success are ultimately determined by the skills and situations faced by the student. However, examples of different ways to succeed, perhaps provided by students, faculty, and staff with different backgrounds, is the only way students can start to strategize about which of these pathways will work for them.

**Inclusive practice: establish a welcoming space.** As STEM educators, with extensive experience as either a student and/or instructor, it is fairly easy for us to feel comfortable in a science classroom or laboratory. While our experiences shape our perspective, we must recognize that it is unlikely that our students share our comfort. The demands of rigorous STEM curricula, often in a physically unfamiliar space, compounded by lack of classmates or mentors who share your background or experiences, can make science students feel isolated and unworthy of success (2, 13, 25). Therefore, it is critical to implement micro-affirmations, small acts to make students feel welcome (20, 22), so students can focus on attacking the ambiguity of active learning, rather than be distracted by feelings of inadequacy.

Tactics for creating a welcoming environment may be tricky, depending on the size and space in the classroom. Consider arriving a few minutes early and standing at the door to welcome each student into the room. A simple, “It’s good to see you,” can go a long way. Make sure all students and instructors have access to current photos of students with their preferred names. For example, on the first day of class direct groups of students to write their names on a whiteboard and take a picture of the students pointing or standing by their name. Post photos somewhere easily accessible, either physically in the classroom or online. Whenever new groups are formed, students should introduce themselves and share something about themselves.

Careful consideration should be taken when determining where students sit. Take a look around your classroom. If left to their own devices, do students cluster? Are some students not receiving the benefits of group work due to seating arrange-

ments? Be bold with seating assignments, and do not be afraid to make changes when things are not working. The simple act of counting off into groups, and counting off again the next day, helps prevent the inadvertent exclusion of some students.

A welcoming space should go beyond the classroom. For example, if a student has been absent or not engaged in class, an e-mail or conversation noting that you have noticed a change in their behavior and inquiring if everything is all right (without the expectation that you are going to resolve the issue), is generally more productive than only stating that they are struggling in the course.

**Inclusive practice: humanize yourself and ask students to do the same.** Much of active learning asks students to be vulnerable. As an extension of creating a welcoming space, share something about yourself, possibility showing some of your own vulnerability. Sharing makes educators more relatable, increasing the likelihood that students will allow themselves to be more vulnerable, and therefore, engaged in the active learning process. In addition, sharing something about you provides a potential point of commonality and connection with students, providing an opportunity to encourage engagement. Asking the students to share something about themselves in return, and then engaging their responses, heightens this connection. Some instructors may find this interaction awkward or uncomfortable, or simply a waste of time. However, by following a few simple guidelines and after some practice, humanizing yourself through sharing provides a wealth of information about your students and substantial social capital for further engagement.

An opportunity to present yourself as a human is typically presented on the first day of class. A very common exercise is to ask students to introduce themselves. There are some advantages to this activity. It is an opportunity for students to practice speaking in front of the class and possibility gain confidence for future class contributions. It also establishes a norm that everyone will be asked to participate and everyone’s opinion will be respected. This activity can be extremely productive, but consider some guiding principles to this interaction.

Carefully consider your prompts. In addition to their preferred name and pronouns, ask students to share something that is commonly understood across cultures, but allows for individuality. For example, sharing favorite foods and/or desserts allows students to share a bit about what makes them happy, and it allows for further engagement through follow-up questions. Another possibility is sharing favorite superheroes. A word of caution: avoid topics that inherently reinforce inequity through establishing a socioeconomic, class, or power hierarchy. One such traps is publically asking students about their favorite travel spot or what they did during break.

Another potential pitfall is asking students to speak in front of the class is inherently inequitable and could be unwelcoming, as some students have substantially more experience speaking in front of groups than other students. In a very early interaction, such as introductions on the first day, those who are less practiced may fade into the background, a status they may not be able to shake over the duration of the course. Therefore, provide time for students to write down their answers and share with at least one other person. This allows students to develop their ideas and gain confidence before sharing with the class.
Publicly sharing your own answers first also helps everyone gain some comfort.

Inclusive practice: promote thoughtful participation. Many best teaching practices require student discussions and group work, which promote ownership and a connection to the course content (5). However, these interactions can favor students with the fastest, not always the best, responses. Implementing a modified “think-pair-share” approach, by asking students to write down answers before they speak, facilitates answers that are more thoughtful (21). Writing in response to prompts allows students with less experience or comfort talking in front of a group to develop their response before speaking. In addition, consider a class citizenship grade, rather than a participation grade. Allow the students in the class to work collectively to define excellent class citizenship.

An effective way to promote inclusive engagement is to assign group roles; a recorder to write down group responses with the class, and an enforcer responsible for making sure everyone’s voice within the group is heard.

Takeaways and Next Steps

A diverse STEM workforce is an opportunity for novel and creative innovation (18). Inclusive teaching practices preserve and enhance the diversifying student population by creating a supportive environment that provides a variety of approaches to success. Strategies that enhance the confidence and support the experience of a diverse student population 1) enhance the learning of all students, 2) support STEM innovation, and 3) decrease social disparities in science education.

I leave you with one final reflection assignment.

Reflective Writing 5: What can I do in my classroom this week to make it more inclusive? What changes can I promote in my department, program, or institution to promote the success of a diverse student population?

As a last step, if you feel comfortable, talk about these writing exercises and your answers with your colleagues, faculty, and administrators. Ask them to go through the same exercises and have open discussions about collaboration and action around the issues of diversity, equity, and inclusion to support the success of your students.

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K.M.S. Johnson is a professional development and programmatic improvement consultant for Trail Build, LLC. Trail Build, LLC is currently a contractor for APS.

AUTHOR CONTRIBUTIONS

K.M.J. conceived and designed research; drafted manuscript; edited and revised manuscript; approved final version of manuscript.

REFERENCES