A CALL FOR BEING HUMAN IN UNDERGRADUATE STATISTICS

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There are many calls for humanizing STEM, including statistics. We begin this paper by providing an evidence-based analysis of the ways in which personal experiences, community structures, and power dynamics may shape the data analysis cycle. Next, we introduce an interdisciplinary framework developed at our U.S.-based liberal arts college—namely, "Being Human in STEM" (HSTEM). The HSTEM initiative helps students understand and navigate their identities (and associated privileges and biases) in academia by reflecting on their own lived experiences, engaging with empirical evidence on inequities in STEM, and then developing an action project to enhance STEM inclusion. Finally, we share lessons learned from multiple iterations of this course and discuss how to adapt the HSTEM framework to create a more inclusive, humanized, undergraduate statistics curriculum.

INTRODUCTION

There have been numerous calls for making STEM (Science, Technology, Engineering, and Mathematics), and higher education more generally, more inclusive in recent years (e.g., Takayama et al., 2017; Tienda, 2013). Many of these inclusive efforts have focused on increasing the sense of community in the classroom and the emphasis on each individual as a whole and complex human. Some teachers implement edutainment modalities such as songs to humanize the way they teach (e.g., Lesser et al., 2019). Some STEM educators humanize themselves with personal storytelling and building interpersonal interactions and relationships with students to create an inclusive learning environment (e.g., Grantham et al., 2015; Johnson, 2019). Still others explore humanizing STEM education through social justice (antiracism, decolonized) pedagogy and critical race feminism (e.g., Kokka, 2018).

As a field, statistics has come to realize the importance of data ethics (e.g., Gelman, 2018)—how we plan research studies, collect data, minimize participant risks, and treat data in our statistical analytic approaches. What has become more apparent and not yet fully attended to, is the role of the *human* in the designing and doing of statistics. What are the roles of our subjective selves in statistics? Unquestionably, our *lived experiences* and biases are deeply embedded in our decision-making processes and influence the nature of the research questions we ask in studies, the data samples we prioritize in collection, the statistical methodologies and models we choose to wrangle and analyze the data, and the angle of the interpretations at which we intentionally or unintentionally arrive. Thus, it is crucial for today's students to be equipped with abilities to reflect on their own *privilege* and *positionality* and to identify potential *biases* they may carry into their statistical thinking and data analysis. At the same time, it is equally important, we argue, that statistics educators and experts also model the process of reflecting on, naming, and seeking to disrupt our own biases in our teaching and statistical practices.

LIVED EXPERIENCES, COMMUNITIES, POWER DYNAMICS, AND DATA ANALYSIS

Lee, Wilkerson, and colleagues (2021) assert that discussions of teaching and learning in the fields of statistics and data science must attend to the *human dimensions* of data work. They highlight several potential risks for failing to do so, such as the development of biased data-reliant algorithms, rushed attempts to teach specific marketable skills and programming languages (rather than strengthening students' statistical understanding and foundations), and "a general lack of critical *reflection* about why students should learn about data" (p. 665). Lee and colleagues also provide a synthesis of multiple lines of research from statistics education, science education, learning sciences, and new media studies, in order to identify three "layers" by which students reason with data:

- *Personal Layer*: Students' *personal and direct experiences* with data contexts inform not only how data are collected, measured, and manipulated, but also how students then reason with data—including, but not limited to, how they pose research questions, design experiments or observational studies, visualize data, and describe patterns in exploratory data analysis (see references in Lee, Wilkerson, et al., 2021). In particular, Lee, Drake, et al. (2021) investigate how

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a student's prior knowledge is used in the data sense-making process, especially when the data are related to their own physical experiences; their work addresses that "remembering" is involved in data interpretation as "a reconstructive act that draws from both general and specific embodied resources and that the work of reconstructive remembering in the classroom is both *individual* and multi-participant work" (Lee, Drake, et al., 2021, p. 367).

- *Cultural Layer*: The second layer concerns the cultural and socio-technical norms and values in data generation and analysis, including disciplinary practices developed within science and statistics *communities* that often determine the kinds of statistical approaches used in the data analysis cycle. Students typically consider scientific evidence as objective, indisputable fact, ignoring the cultural and disciplinary norms that may have impacted the nature of the data collected or analyses conducted, and the opportunities for open dialogues and interpretations. Indeed, research has explored the processes by which students commonly "objectify" evidence. For instance, Manz (2016) proposed a framework to study how evidence is constructed by classroom communities—students first develop consensus by examining how observations can be counted as data, next use some data as evidence to link them with claims, and eventually transform those claims as new "communally accepted knowledge." Their investigation helps shed light on how data practices and tools are developed in communities, as well as how existing disciplinary norms and cultural standardization inform those practices and tools.
- *Sociopolitical Layer*: Social and political narratives affect the ways data are collected, constructed, interpreted, and used—which also reflects the *power dynamics* we endure and/or benefit from. This layer is least well studied and least fully considered by STEM educators and researchers, although several studies have revealed how data are used to reproduce racism or increase systemic inequities through biased algorithms and "big data" (e.g., Noble, 2018; O'Neil, 2016), all addressing the importance of raising students' awareness and attention to those concerns. Some researchers have further questioned traditional educational approaches to data analysis because they can neglect (marginalized) students' perspectives (Enyedy & Mukhopadhyay, 2007) or fall short in considering the impact of existing power dynamics on shaping how and why data are used (Van Wart et al., 2020).

Lee, Wilkerson, et al. (2021) further acknowledge that these layers can operate individually, and they also frequently interact with each other. For instance, *students' identities* are not only personal, but also cultural as they consider their *positionality* within a certain classroom or community; in the meanwhile, identities are also made up with broader social narratives such as race, gender, disability, and other factors of power. Like Lee, Wilkerson, et al. (2021), we believe that STEM educators cannot meaningfully engage students with any data analysis without helping them fully understand the layers of personal, cultural, and sociopolitical factors that shape their engagement with that data. We also believe in the necessity and urgency of helping next-generation statisticians and data scientists understand and navigate their unique *identities* and *positionalities* in academic and beyond, as well as potential *implicit biases* they may carry into their data analysis work. To address those needs in modern statistics and data science education, we propose the integration of a cross-disciplinary course—or at least some of its components—as described below, into the undergraduate statistics curriculum.

OVERVIEW: BEING HUMAN IN STEM (HSTEM)

The "Being Human in STEM" (HSTEM) course emerged in response to student calls for institutional change and a moment of institutional crisis. In November of 2015, three Black female students at Amherst College arranged a one-hour sit-in to protest anti-black violence and to be in solidarity with other campuses across the country who were also protesting acts of discrimination, marginalization, and harms committed towards students and persons of color. This one-hour sit-in quickly grew into a four-day occupation of the Amherst College Frost Library, a central campus building. During this event, now referred to as "The Amherst Uprising," student after student stood to share their experiences of marginalization and exclusion at the College. Many faculty and campus administrators attended the Uprising; many did not. Students in STEM disciplines noted that many of their instructors were not in attendance. In response, students wrote letters to their departments, asking for their support and seeking ways to partner with them to enhance inclusivity at the College. One such effort that arose as a result was the "Being Human in STEM" (HSTEM) course. First taught as a special topics course enrolling nine students in Spring 2016, the HSTEM course has now been adopted or is in the process of being adopted at 25 institutions across the U.S.

The HSTEM model, the core of the HSTEM course, infuses each aspect of the course design. This model, which is a cycle of *Listening* → *Validating* → *Reflecting* → *Partnering*, encourages students to engage in *self-reflection* about their lived experiences in STEM, learn to listen to and appreciate the experiences of others, connect these experiences to the larger literature on STEM equity and inclusion, and then build partnerships with other institutional constitutes to identify and implement action projects aimed at inclusive institutional changes.

One of the signature assignments of the HSTEM course, at least as it is taught at our home institution, is the Being Human in STEM (HSTEM) Story assignment. In this assignment, students and instructors construct a representation (e.g., written, visual, audio, etc.) of their journey in STEM up to the point of arriving at the HSTEM class. What were the positive and negative experiences in STEM that have been important to them? What have been the advantages, obstacles, catalysts, failures, and surprises that they have experienced in their STEM journey so far? Once individuals have constructed these narratives, they then share their HSTEM stories with others in the course, and, throughout the course of the semester, refine and expand on their stories as they build an increased understanding of the STEM literature and the roles of their *identities, lived experiences, positionality*, and *culture norms* that contribute to STEM experience.

LESSONS LEARNED FROM HSTEM

In reflecting on the experience of being a student in HSTEM, students commonly report that learning about others' experiences in STEM, and reading the empirical literature on diversity, equity, and inclusion (DEI) issues in STEM, allows them to recognize that their experiences of isolation or challenges in STEM are not individually experienced events, but rather part of larger systemic issues. They feel an enhanced sense of community and connection to their peers in the course after having gone through this learning experience together. And, when activities from the HSTEM handbook—an HSTEM student-developed handbook that outlines a series of inclusive practices for STEM classrooms and laboratories—are integrated into introductory STEM courses, we also see that students report an increased motivation to persist in STEM (Bunnell et al., 2021). Thus, the importance of emphasizing the *building of community* and allowing space for *reflective processes*, both for HSTEM students and faculty, are two important lessons that we have learned about how to structure a HSTEM course successfully.

The HSTEM handbook, mentioned above, is one example of the myriad action projects that students in HSTEM have developed over the past 6 years. Regardless of the nature of the project itself, another lesson we have learned is the importance of *engaging students* in the development of action projects or action project proposals. This assignment allows students to leverage their newly refined knowledge, of themselves, of others, and of institutional and systemic challenges, to identify meaningful and possible avenues for change. The process of developing an inclusive action project for their community dramatically increases students' sense of agency as a student at the College, far beyond the scope of the course. For example, several HSTEM alumni at Amherst College partnered with the chemistry department to form an anti-racism departmental committee while other HSTEM alums at Amherst worked with the biology department to add an equity and inclusion-focused course as a major requirement. Most recently, a group of HSTEM alumni helped the mathematics and statistics department organize and host a Being Human in Math & Stats colloquium series in spring 2022, which has promoted impactful conversations on accessibility and equity between current students and alumni of both math and statistics majors.

A fourth lesson we learned from multiple iterations of the HSTEM course is the value of *interdisciplinary co-facilitation* of the course. While not essential, the learning outcomes for both students and facilitators are enhanced when the course is co-taught and the instructors have different disciplinary affiliations. Why is this particularly important in HSTEM? The pedagogical approach to teaching HSTEM is one in which each member of the course, students and facilitator alike, adopts a stance of being a co-learner. As faculty trained in a STEM discipline, facilitators hold expertise in their discipline but typically are not experts in the field of inclusion. As such, we encourage faculty to name points of confusion as they emerge. Having a faculty co-facilitator in the classroom allows for enhanced opportunities to challenge one's disciplinary assumptions and model not-knowing.

INTEGRATING HSTEM INTO STATISTICS CURRICULUM

Although we strongly believe that the aforementioned HSTEM course would benefit *all* STEM students, these skills of listening, validating, reflecting, and partnering are critically important for those in statistics and data science. A "Being Human in Statistics" course would not only engage students with the nation's pressing issues of antiracism and DEI (diversity, equity, and inclusion), but such a course would also equip future statisticians and data scientists with capacities to be mindful about the three layers of humanistic factors in data practices. More specifically, we urge statistics and data science educators to consider integrating the HSTEM ethos and the lessons learned from HSTEM into their undergraduate curriculum. Below we present our suggestions.

Building an Inclusive Learning Community via Inclusive Practices

Building an inclusive learning community, in-person or online, is the most critical first step toward effective and meaningful education, and this becomes increasingly important as more and more colleges and universities across the country open their doors to a more diverse student body. Bell Hooks (1994) states in her book, *Teaching to Transgress*, "As a classroom community, our capacity to generate excitement is deeply affected by our interest in one another, in *hearing* one another's voices, in *recognizing* one another's presence" (p. 8). It is important for us to take time to build rapport with students and help them connect with each other. We recommend beginning with humanizing ourselves by sharing our "Being Human in STEM Story," both successes and failures, and modeling vulnerability. After connecting with our students in this way, we can next help students to better know each other. We love our "HSTEM family album," which consists of shared Google slides, one slide for each class member (including faculty). On their slide, each individual shares something they feel comfortable sharing about themselves with the class, such as their photo, hobbies, favorite music/books/food, etc. Another inclusive practice we implement in HSTEM is the use of student "pods." In this practice, we divide students into "pods" of 3–4 students and begin each class with a brief "pod chat" to allow students to check in with each other and to continue strengthening relationships through the semester. More useful inclusive practices for STEM classrooms can be found in our student-initiated (and faculty- and staff-refined) HSTEM handbook on the HSTEM website at http://www.beinghumaninstem.com or in Johnson (2019).

Allowing Space for Reflective Processes as Part of Student Learning and Faculty Teaching

Higher education should be about not only passing knowledge to the next generation, but also helping young adults understand who they are and explore whom they want to be. We firmly believe that meaningful teaching and learning should always begin from within, and we always allocate time and space for reflective practices in the HSTEM course. Long ago, Baird et al. (1991) demonstrated that collaborative reflections can promote positive cognitive, metacognitive, and affective outcomes in science classrooms, benefiting both teachers in teaching and students in learning. More recently, Finlay (2008) describes reflective practices as "the process of learning through and from experience towards gaining new insights of self and/or practice" (p. 1), which can help us increase our self-awareness on hidden assumptions of everyday practice and critically evaluate our own responses to practice situations. Such self-consciousness and inward-thinking abilities are particularly important for statistics students, we argue, as they help raise awareness of the aforementioned personal, cultural, and sociopolitical layers of data practices. In addition to the Being Human in STEM Story activity described above, we also encourage educators to allow time for students to reflect on the practice of learning in class—for instance, allowing a few minutes of silence for students' self-reflection before entering into whole class discussions, or asking students to use the last few minutes of the class time to reflect on what they learned for the day.

Engaging Students as Co-creators and Partners of the Course

A secret ingredient of HSTEM success is the deep involvement of our students in the creation of course projects, which often result in real actions for DEI changes on campus. Such engagement empowers our students, elevates their voices, and makes them excited about learning. There are many ways to integrate this idea in undergraduate statistics curriculum. As one example, statistics instructors can involve their students in the process of generating course material by co-creating the course structure with students or asking students to make collaborative answer keys for homework assignments (Sabbag & Frame, 2021). As another idea, statistics educators can also design course projects around emerging issues that directly impact their life or the society; guide students to use statistics as a powerful tool to gather useful information and identify potential problems behind those issues; quantify statistical evidence; and then encourage students to use that empirical evidence to come up with some actionable solutions, big or small, for the problems they identified. For instance, to address the pressing issue of mental health crises in universities, students can develop a self-care action project for which they will need to first reflect on how they take care of their own well-being, then explore scientific studies on various self-care exercises (which often use a lot of statistical methods or reasoning); propose one actionable strategy to help promote mental health of themselves, their peers, and the community; and then conduct a statistical exploration into the impact of that practice on campus wellbeing. We believe that responsibilities behind those co-creation activities would not only engage students more deeply in their statistical learning but also advance their leadership skills in their scientific research.

Inviting Perspectives and Learning from Humanities

Statistics, by its nature, is an interdisciplinary field, and many statisticians collaborate with experts from other STEM disciplines to acquire needed domain knowledge for data analysis. However, the traditional undergraduate statistics curriculum rarely addresses the importance of humanities learning in our classrooms. Recent research has revealed many positive learning outcomes that result from integrating humanities and arts with STEM (National Academies of Sciences, Engineering, and Medicine, 2018; Tuana, 2013)—such as "increased critical thinking abilities, higher-order thinking and deeper learning, content mastery, problem solving, teamwork and communication skills, improved visuospatial reasoning, and general engagement and enjoyment of learning" (National Academies of Sciences, Engineering, and Medicine, 2018, p. 3)—which echo the fourth lesson we learned from the HSTEM course. We encourage statistics educators to identify avenues for learning from their humanities colleagues and to incorporate selected readings about theories and perspectives from humanities—such as those that highlight feminist theory, indigenous knowledge, and explorations of scientific objectivity—in their teaching. By expanding students' exposure to a wider framework and tools for making sense of the world, they will be better prepared to engage with human dimensions of data work and, in turn, operate as more responsible and ethical statisticians and data scientists. As a starting place, we highly recommend books written by Bell Hooks on the topics of feminism, classism, and racism.

CONCLUSION

Too often, data practitioners use data without fully considering the humanistic aspects of data work, by treating data as objective, apolitical, and immune from cultural norms. Consequently, the resulting data analysis and statistical evidence are believed by these practitioners to be inherently objective and bias-free. We think that this approach to data work does a disservice to students studying undergraduate statistics, and we present the HSTEM course model as one mechanism for integrating a more holistic understanding of data analysis into the undergraduate statistics curriculum. Indeed, our Department of Mathematics and Statistics recently approved the HSTEM course as an elective course within our statistics major, after substantive departmental discussion. The concerns raised by some departmental colleagues were two-fold: (1) content-wise, this course is very different from other traditional statistics electives we currently offer; and (2) none of our statistics faculty had been trained to teach such a course. Thankfully, Amherst College has seriously committed to antiracism actions in recent years and urged all departments to integrate DEI-related learning into our courses and curricula; in so doing, the HSTEM course content is more readily justified as a key piece of the STEM curriculum. Secondly, the College has provided resources to support faculty members' development of expertise in inclusive and antiracist teaching, including granting full teaching credit for new HSTEM instructors to co-teach with experienced facilitators, and offering the Being Human at Amherst Summer Institute in 2021, which helped many interested faculty from different disciplines, including statistics, learn more about the HSTEM model and approaches. It is our hope that other statistics and data science educators will also consider taking a brave step forward and adding a similar course or integrating some HSTEM lessons into their undergraduate statistics curriculum in the near future.

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