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Candice Price

Credits

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Intersections of Mathematics and Society

Ranthony A. C. Edmonds and John H. Johnson Jr.

Introduction

At the undergraduate level, most mathematics programs and courses don't devote time to discussing how mathematical communities are formed and maintained. Instead, mathematics is often presented as a collection of "eternal truths and objective algorithms" that are discovered (or invented) and simply passed on from one generation to the next. Outside of perhaps one history of math course, little regard is usually given to the larger social and cultural milieu that supports and sustains mathematical communities. We claim this is one—but not the only—reason many students and practitioners feel "disconnected/isolated" in math. This is especially true for Black, Indigenous, and other people of color.

In our course, *Intersections of Mathematics and Society: Hidden Figures* at The Ohio State University, we directly addressed the connection between the creation of mathematics, its developments and applications, and society. We also emphasized the importance of a strong mathematical identity as students try to join, be accepted, and valued as a member of various mathematical communities. To do this, we centered our focus on mathematical community via the *Hidden Figures* text by Margot Shetterly [She16].

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Our effort ties into the larger landscape of instructors using culturally competent pedagogy. Culturally relevant practices are tied to three overarching instructional pillars: (1) academic achievement, (2) cultural competence, and (3) sociopolitical consciousness. While the first pillar is already a staple of the college mathematics classroom, the subsequent two may feel less familiar in a mathematical context.

Culturally competent practices give students a way to develop their own mathematical identity in addition to providing insights into the lived experiences of others within the mathematical community. Sociopolitical consciousness provides students with an understanding of the interplay between mathematics and the social and political issues that impact local communities and the world at large. These perspectives allow for a holistic view of mathematics, where students consider not only the conceptual frameworks that permeate our courses, but the historical and political context in which mathematics is created and used.

In this article, we highlight tips that may be helpful for those considering designing a new course or redesigning an existing course at their institutions so that it incorporates cultural-competent practices. These tips are related to elements of our course that we found the most successful for creating the learning environment we desired, and that can be implemented in any course, regardless of the content. We also describe our hidden figures course in more detail.

Tips for Course (re)Design

In this section we provide tips for course design related to components from our course that were inspired by a focus on the intersections of mathematics and society, and rooted in the three pillars of culturally competent pedagogy highlighted above. We focus on (a) embedding reflection within a course, (b) involving students in outreach and service learning, and (c) highlighting external voices.

Embedding Reflection within the Course

- Intentionally include reflective (or extension) questions in computational assignments. In a calculus course, for example, a question could be included in an assignment about derivatives that asks students to find three real-world applications of derivatives in their major field.
- Consider adding ongoing reflections related to a course theme you want to emphasize throughout the term. (In our course we had several service-learning specific reflections, the first asking students to reflect on their own experiences with service learning along with the potential impact of their outreach on the local community, and the last asking them to reflect on the process of developing STEM programming and on the utility of service learning to increase access to mathematics.)
- Incorporate reflection into the course by utilizing online forums for discussion. Be clear about the

rules and expectations for communication in online environments; include examples of appropriate and inappropriate responses.

- Make sure that most online reflections involve a component that requires students to respond to each other. Give students time to do this intentionally. (In our course, students had one day to respond to two additional classmates after their initial posting was due.) In a large class, break students into smaller groups online, and have them respond to their group members after an initial posting.

Outreach and Service Learning
- Try not to reinvent the wheel. You do not have to start your community engagement efforts from scratch! The best way to start is by plugging in to existing efforts. Most local school districts and community centers (like the library system in Columbus) have STEM and/or college readiness initiatives and are often in search of volunteers. Many corporate websites have an outreach and community engagement tab, with a list of activities and a point of contact.
- Consider utilizing an appropriate person within your department or college or undergraduate students to help you with coordination. This helps avoid the need to manage the moving parts of setting up volunteer opportunities alone.
- Outreach can be more than student presentations. It is possible to create mathematical course "artifacts" that community organizations can use for STEM education. (This was one adaptation for our course due to COVID-19.)
- Have students workshop a service-learning project in class. This class time should be structured with clear objectives for each period in terms of progress. (We carefully scaffolded the development of our students' service-learning programming, beginning with students brainstorming their ideas as individuals, sharing these ideas, and then determining several programming ideas that incorporated everyone's vision.)
- Include assessments (brief follow-up surveys, online discussion board posts, etc.) that require students to reflect on outreach and service-learning experiences in a meaningful way. As an aside, an intentional cycle of service and reflection is the key difference between service learning and experiential learning.

Collaborations and External Voices
- Invite other instructors to speak to your course to fill gaps in your knowledge about the intersections of history, culture, and STEM. (We had a professor from the Department of Women, Gender, and Sexuality Studies come and speak to our students about the historical context of the *Hidden Figures* story, which led to a deeper understanding and appreciation of the mathematical contributions of the women in the text.)
- Invite STEM professionals to discuss their career, research, and the mentors and community that aided them on their path. Ideal speakers will be able to speak to ideas and experiences related to course themes.
- Consider adding "nontraditional" STEM books as part of required reading in the course. (We had our students pick three stories in the MAA and AMS's *Living Proof: Stories of Resilience Along the Mathematical Journey* [HLPT19] as a precursor to a course discussion about the myth of a "math person" and challenges that can arise when pursuing mathematics.)
- Incorporate a "mathematician of the week" as part of your course. Two great sources for contemporary mathematicians are `Lathisms.org` and `MathematicallyGiftedandBlack.com`.

Integrating reflective components into a course provides an avenue to address all three pillars of culturally competent practices. Intentionally structured discussion prompts offer the opportunity to deepen conceptual understanding of course concepts, as well as to position course ideas within larger social and political frameworks. We found that these reflective components greatly added to a sense of community in our course, and allowed for the modeling of appropriate ways to engage in intellectual discourse related to diversity and inclusion in mathematics.

Outreach and service-learning opportunities allow students to interact and serve communities similar to or different than the ones they grew up in. When facilitated appropriately, these experiences increase the cultural competencies of our students. Incorporating experiential learning also has the effect of highlighting the value of service as part of science.

Using colleagues and community members as instructional resources is a valuable practice when developing curricula that are culturally responsive. It alleviates the pressure of becoming an expert in historical and contemporary subject matters outside of mathematics, increases instructor and student knowledge of local and academic resources, and increases exposure to the intersection of mathematical ideas and society.

Our Hidden Figures Course

Both authors were inspired after reading the text, *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race* by Margot Shetterly [She16]. Shetterly's book provides a brilliant view of how society and mathematical and scientific advancements were intertwined with the story of four black women mathematicians—Dorothy Vaughan, Mary Jackson,

Katherine Johnson, and Christine Darden—roughly during the period from 1940–1970 in the United States. Socially, in the US, this period of time covers World War II, segregation throughout the US and Jim Crow laws in the American South, postwar civil rights protests and activism, and culminates in the Second Reconstruction (or Civil Rights Movement and accompanying legislation).

Scientifically, this period of time covers the development of the atomic bomb, the growth and expansion of the aeronautics industry (such as the National Advisory Committee for Aeronautics (NACA), the precursor organization to NASA), and the Space Race which contributed to the rapid growth of the mathematical (and scientific) communities whose expansion provided the foundations for much of our current technology.

Due to our focus on the intersections between mathematics and society, our course is positioned as a special topics course within the Department of Mathematics. We believe this course is well positioned to serve as a model for a contemporary history of math course at other institutions; components of the course can be included in regular course offerings, and the course themes and components could form the basis for a redesigned introductory seminar.

These themes motivated the design of the course around three major outcomes for our students:

1. Understand the role of mathematical communities, how they are formed and maintained, how membership is mediated, how community members are "valued" and promoted, and the mathematics and computational tools that they use.
2. To interview and engage with "local Hidden Figures" from the Greater Columbus Community, to learn how they apply mathematics in their own professions and understand how personal and professional communities have played a role in their career.
3. Create local mathematical communities of their own, emphasizing the importance of mathematical communication along with community service related to service learning. (The implementation of community service was ultimately changed and modified in the Spring 2020 pilot with the switch to remote instruction due to COVID-19.)

Below we briefly describe some of the activities that addressed the outcomes noted above. In particular, the first half of the semester of the course addressed outcomes 1 and 2, while the second half of the semester addressed outcome 3. For general information about the course please visit math.osu.edu/courses/2010s.

First Half of Semester

Students were given a brief biography of each local Hidden Figure and asked to rank order the local Hidden Figures they would like to interview. Based on students' surveyed preferences, students were arranged into small groups and each group was assigned to a local Hidden Figure. We provided guidance (for example, template emails and suggested timeline) on how the groups should make contact with their assigned local Hidden Figures and handle scheduling.

Students interviewed their local Hidden Figures in order to complete two group projects. The first project required students to analyze their local Hidden Figures' backgrounds and professional journeys using intersectionality and community as a framework.

In the second project students created a report about the mathematical tools used by their local Hidden Figures appropriate for a lay mathematical audience. To help the students understand these mathematical tools, the instructors held several consultation sessions with each of the groups to provide necessary mathematical background and point to supplemental resources. Tools ranged in scope from Catia 3D software modeling used in engineering, to techniques of logistic regression and data visualization techniques using Microsoft Excel.

Students were also issued a Post 1460 Versalog Slide Rule, an engineering-grade computational device comparable to what the Hidden Figures in the text would have used at NACA/NASA. We dedicated a significant portion of class time to understand their construction (they use a logarithmic scale to perform operations such as multiplication and division) and operation. Students also read the *Hidden Figures* text, and completed weekly online reading quizzes and discussion-board posts related to the readings. This allowed us to focus on different mathematical ideas present in the book outside of our dedicated discussion days, while still creating a rich dialogue about the text.

Second Half of Semester

The second half of the semester focused on the service-learning portion of the course. We established a community partnership with the Columbus Metropolitan Library (CML). Students would deliver an original STEM program related to course material to library patrons at select branches. During the second half of the semester, we allotted two days of class time a week so that students could work on these projects together in class, keeping the third day for discussions about assigned readings.

Ultimately, students developed a worksheet that would teach basic computations with the slide rule (multiplication and division), as well as a brief presentation on select historical facts about certain Hidden Figures in the text for students at the local library branches. As a result of COVID-19, instead of facilitating the worksheet and presentation in person, students delivered a "program kit" that could be administered by library personnel who had access to suitable training regarding the slide rules.

References

[HLPT19] Allison K. Henrich, Emille D. Lawrence, Matthew A. Pons, and David G. Taylor (eds.), *Living Proof: Stories of Resilience Along the Mathematical Journey*, American Mathematical Society and Mathematical Association of America, Providence, Rhode Island, 2019.

[She16] Margot Lee Shetterly, *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race*, Harper Collins Publications, New York, NY, 2016.

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Designing a Course Connecting Mathematics with Latin American Cultures

Colleen Duffy

We teach what we love; I love both mathematics and exploring other cultures. I had a strong desire to combine my interest and studies in Latin American cultures with mathematics, and hence the course entitled *Mathematics in Latin American Cultures* was born. Its course catalog description is:

> This course introduces important mathematical concepts and topics, such as number and arithmetic systems, symmetry, and data structure, using the cultural lenses of pre-Columbian Latin American indigenous cultures.

In this article we will explore how my interest in such a course developed, the logistics of designing a new course, and how to connect mathematical ideas with cultural components.

Background

I have always had a strong interest in exploring other cultures, peoples, and places. My family hosted an exchange student from Chiapas, Mexico, my senior year of high school, and she became a member of our family. Through several trips to visit her, I have been able to see first-hand

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several historical sites of the Maya peoples and to see some of how indigenous peoples today are connected to them. I double majored in mathematics and Spanish in university. During my semester abroad in Salamanca, Spain, I took a course on Spanish and Portuguese colonialism in Latin America. And, during graduate school, I went to Peru where I visited several Incan historical sites including Macchu Picchu. These experiences naturally led me to consider how I could incorporate a new perspective, and specifically an indigenous Latin American perspective, into a mathematics course. Furthermore, I have been able to enrich the course with stories and pictures from my travels. While my background prepared me for teaching a course based on Latin American culture, there are a lot of resources available to get you started in developing your own course if you do not have such a background. I mention some resources below.

Logistics

Our university and department espouses interdisciplinary collaborations in course work and research, so institutional support was not a concern in deciding to develop the course. At the end of my first year at the university I talked with the chair of my department to get his support in developing this course. I then found a colleague, Dr. Manny Fernández, in the Latin American and Latinx Studies (LAS) program who was interested in co-developing the course with me. It was invaluable to have his expertise on the cultural side of things, and fun to collaborate on ideas. We also brought two students into the project: a mathematics education major with a Spanish minor as well as an LAS major. We received financial support through our Office of Research and Sponsored Programs to pay the students a stipend to work on developing the course with us. Our university also now has funding for faculty to develop or revamp a course; so, it is worth checking into funding options. We developed it over the course of the year 2009–2010, and offered the course the following spring 2011.

The University of Wisconsin–Eau Claire, like many colleges, has a liberal education math course focused on introducing a variety of mathematical topics that the students have likely not seen before; here the course is entitled *Introduction to Mathematical Thinking*. This type of course provides a good platform to try a new course. There is a lot of paperwork involved in getting a new course in the catalog, so we decided to pilot our course as a special section of *Introduction to Mathematical Thinking* first. Because we have a lot of flexibility as to topics covered in the course, this was possible for us. Starting by introducing a project or a couple of topics in a course would also be a way to build up to designing a new course. Another possibility would be to offer a seminar or honor's course. Fernández and I co-taught the first two iterations of the course. Student interest was high enough that the mathematics department and the LAS program were interested in having it be its own course after that. It is housed in the math department