Barriers exist to first-generation students pursuing higher education (e.g., lack of knowledge of opportunities, financial constraints), and further challenges exist as these students transition into their graduate studies. The majority of doctoral students "use their family's collected history and knowledge to inform their graduate school experiences" [Gar13, pp. 47]. Still, thirty percent of the earned doctorate degrees [Nat16] are first-generation students, which means that a significant proportion of the graduate students today experience feelings of "otherness" and living in "two worlds" [Gar13; GH11]. In other words, they often lack a cognitive map to help them navigate higher education. The *cognitive map*, defined in [Lov01], is a mental coping mechanism, fostered from a young age, used to understand experiences and to provide a basis for decision-making. As a first-generation student myself, helping build that cognitive map and supporting first-generation scholars motivates my outreach and service endeavors by creating and promoting a welcoming community. Many of the first-generation students are also underrepresented in STEM fields on additional axes (e.g., gender, race, ethnicity, socioeconomic status), and the intersectionality of these identities is compounding. Below, I explain my sustained efforts for creating a welcoming community and sense of belonging through: leading local K-12 outreach through the *Storytelling Project*, establishing the WinCompTop research network, and participating in efforts to support recruitment and retention of graduate students.

Storytelling: K-12 Outreach in Montana   While my primary research is in computational topology and geometry, I am also interested in STEM education, specifically as it relates to broadening participation in computer science (CS) and mathematics. In Montana, the number of students who have access to CS in formal K-12 learning spaces is significantly lower than the national average. For example, in the 2019–2020 academic year, only nine Advanced Placement exams were administered for Computer Science A. Of those who took this exam, none were women, Latinx, Black, or American Indian [Cod20]. Moreover, Montana has a large population of lower socioeconomic and rural communities, where access to CS is limited by inadequate infrastructure, resources, and interest; this interest is critical for choosing to pursue further opportunities in CS [GPC16]. One way to increase student interest in Montana is through culturally responsive computing. Funded through two NSF grants (DRL 1657553 and DRL 2031795), I am leading a diverse team of researchers at MSU to develop middle school lesson plans that teach computer science through storytelling in the drag-and-drop programming environment Alice[1], and with physical computing using the Circuit Playground Express (CPX) that allows students to use drag-and-drop browser-based MakeCode to program lights and sounds of a small devise. The lesson plans we develop meet Montana content standards and address the Seven Essential Understandings (EUs) of the Montana Indian. The EUs are part of the constitutionally-mandated teaching of Indian education in Montana classrooms. The project uses a culturally responsive approach to infuse CS into the classrooms via storytelling in the curriculum (using Alice and physcial computing), guided by Tribal Critical Theory, which maintains that cultural knowledge and academic knowledge are not mutually exclusive but complement each other. We have 11 lesson plans and four outreach modules under development that use Alice and one extended unit with the CPX. We have created a community of teachers interested in integrating CS into their classrooms, run pilots to test the lesson plans, regularly host outreach events, and are working on improving our in-depth teacher training workshop.

Women in Computational Topology   When I began my Ph.D. studies in 2007, very few people were working in (or using) topological data analysis. However, that has changed in recent years. Academics—in mathematics, computer science, and applied domains— are embracing the field of TDA (which goes by several names: TDA, Applied Algebraic Topology, Computational Topology). In 2015, a small group of colleagues and I recognized

---

[1]Alice is developed by Carnegie Mellon University, and is freely available; see `http://www.alice.org/`.

that women in our field are represented more favorably than in most computer science and mathematics fields; yet, conferences and workshops still had relatively few women as invited speakers. This creates a barrier to entry and to feeling included in the community for women, minorities, and especially for first-generation students who are an underrepresented minority. And so, Lori Zeigelmeier and I began the listserv for women in computational topology (WinCompTop), and we, along with Erin Chambers, started to plan the inaugural WinCompTop workshop (WinCompTop 2016, held at the Institute for Mathematics and Its Applications in Minneapolis, MN). The idea behind creating the WinCompTop community is to help spread information within our community, and to be open for anyone to join. The WinCompTop listerv, now with 282 subscribers, is now the de facto place to post advertisements for conferences, job openings, etc., related to TDA.[2]

Additionally, at WinCompTop 2016, I was elected as one of the three community members to serve on an inaugural steering committee, and am continuing to serve on the committee until the next committee election at the next WinCompTop workshop in July 2023. The WinCompTop steering committee has been a valuable resource for conference organizers looking for women and nonbinary invited speakers, for nominating women in our community for awards, for junior researchers in the community looking for advice or to express concern, and for ensuring that WinCompTop as a sustained presence at events such as the Joint Mathematics Meetings and the AWM Research Symposium.

Despite these efforts, we see conferences run without representations of women and editorial boards with limited diversity on multiple axes; however, slowly, I do feel that researchers are becoming aware of the importance of diversity for moving the field forward. As a faculty member who is respected in her research community for academic contributions, I am now in a position where I can speak up when needed. It is awarkward to do so. Yet, when a student emails me to express their concerns and I am able to respond back to say that I have spoken to the organizer (or helped setup a change.org petition), I know that these awkward conversations are worthwhile in the end.

Recruiting and Retaining (Graduate) Students   I lead the Computational Topology and Geometry (CompTaG) research group at Montana State. This group is grounded in the principals of inclusivity and collegiality. It is advertised to all math and CS graduate students each semester, so that everyone feels welcome. Students work in groups to prepare seminar presentations, and provide feedback to each other after presentations. In addition, I leverage existing programs at MSU—such as the McNair Scholars program for first-generation students and the First-Year Experience program for first-year honors students—in order to connect with students with a wide-range of interests and backgrounds.

In Spring 2023 (postponed from March 2020), I will run the Topology for Data Science (T4DS) workshop. This workshop is for undergraduate students, designed to introduce students to data science and topology. T4DS will engage students in a hands-on, collaborative experience, requiring only discrete mathematics and a desire to try something new as prerequisites. We are heavily recruiting from schools that have a high enrollment of first-generation and minority students. Ben Holmgren, a former undergraduate student, who just graduated in May and is currently applying to graduate schools, will be a co-organizer and presenter at this workshop.

Conclusion   Research has shown that interventions that foster one's sense of belonging through academic guidance and mentoring are effective and contribute to enhancing the experience for all students [Phi14]. Thus, through my efforts to increase a sense-of-belonging for first-generation students, women, and underrepresented minorities, all members of the community benefit.

---

[2]If you are interested in joining the WinCompTop listserv, simply send a blank email to WinCompTop+subscribe@googlegroups.com.

References

[Cod20]   Code.org. *Support K-12 Computer Science Education in Montana*. Code.org, 2020.

[Gar13]   S. K. Gardner. "The Challenges of First-Generation Doctoral Students". In: *New Directions for Higher Education* 2013.163 (2013), pp. 43–54.

[GH11]   S. K. Gardner and K. A. Holley. ""Those Invisible Barriers are Real": The Progression of First-Generation Students through Doctoral Education". In: *Equity & Excellence in Education* 44.1 (2011), pp. 77–92.

[GPC16]   S. Grover, R. Pea, and S. Cooper. "Factors Influencing Computer Science Learning in Middle School". In: *Proceedings of the 47th ACM Technical Symposium on Computing Science Education*. SIGCSE '16. Memphis, Tennessee, USA: Association for Computing Machinery, 2016, 552–557. DOI: 10.1145/2839509.2844564.

[Lov01]   B. E. Lovitts. *Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study*. Rowman & Littlefield, 2001.

[Nat16]   National Science Foundation, National Center for Science and Engineering Statistics. *Doctorate Recipients from U.S. Universities: 2015. Special Report NSF 17-306*. Arlington, VA. Available at www.nsf.gov/statistics/2017/nsf17306/. 2016.

[Phi14]   K. W. Phillips. "How Diversity Makes Us Smarter". In: *Scientific American* (2014). Republished Jan. 2017.