Initiating PER collaborations with two-year colleges

Sherry L. Savrda (she/her)
OPTYCs, American Association of Physics Teachers, 1 Physics Ellipse, College Park, MD 20740-3845

Anthony Escuadro (he/him)
Department of Physical Science, Harold Washington College, 30 E Lake Street, Chicago, IL, 60601

Abigail R. Daane (she/her)
Department of Physics and Astronomy, South Seattle College, 6000 16th Ave SW, Seattle, WA 98106

Karim Diff (he/him)
Natural Sciences Department, Sante Fe College, 3000 NW 83rd Street, Gainesville, FL 32606

Kristine P.H. Lui (she/her)
OPTYCs, American Association of Physics Teachers, 1 Physics Ellipse, College Park, MD 20740-3845

The past several years has seen increased interest in expanding physics education research (PER) studies to the two-year college (TYC) physics community. This interest is driven by the knowledge that while a significant portion of the students taking introductory physics courses do so at TYCs, those students are highly underrepresented in PER. The considerable teaching loads and lack of research support for TYC faculty make it difficult for TYC faculty to independently enact PER. Faculty outside of TYCs can build successful, productive, and equitable research partnerships with TYC faculty to alleviate these constraints. In this paper, we review TYC demographics that distinguish those students from populations traditionally studied in PER. We describe the challenges faced by TYC faculty in performing research as well as examples of successful research and scholarship of teaching and learning. Finally, we outline some successful TYC/PER partnerships and share initial recommendations that can inform TYC and four-year college faculty desiring to build effective and equitable PER partnerships.

2024 PERC Proceedings edited by Ryan, Pawl, and Zwolak; Plenary, doi.org/10.1119/perc.2024.plenary.Savrda

I. INTRODUCTION

In recent research, Kanim and Cid (2020) showed that physics education research (PER) subjects tended to be more mathematically prepared and less ethnically and economically diverse than the general population of students taking introductory physics courses [1]. Kanim and Cid found that almost no research was done on students in two-year colleges (TYCs). Since the publication of that paper, interest in research focused on the TYC student has increased. The U.S. Department of Education created several programs targeting community colleges [2], and the National Science Foundation's program for Improving Undergraduate STEM Education (IUSE) has introduced solicitations specifically targeting TYCs [3].

Focusing on physics, the Organization for Physics at Two-Year Colleges (OPTYCs) [4] began in 2022 and has developed programs to support TYC faculty and students through professional development. One initiative encourages stronger representation of TYCs in PER. The program sponsors journal clubs to discuss recent PER articles and the ways in which the results of those studies might apply in TYC classrooms. OPTYCs also facilitated sessions at PERC '23 and '24 [5-6] that focused on increasing and improving equitable partnerships amongst faculty from a variety of institutions, including TYCs.

Below, we will provide data on how students taking physics at TYCs differ from students represented in most PER studies. We will also describe how TYCs students' experiences might differ from experiences of typical students at four-year colleges or universities (FYCs). Finally, we will highlight examples of TYC faculty carrying out action research, enacting PER locally, and forming productive relationships with faculty at other institutions. We end with recommendations for creating more productive and meaningful relationships.

II. TYC STUDENTS

Before considering how TYC and FYC faculty might form working relationships, we will describe how the TYC student population differs from that represented in the majority of PER. These statistics can inform faculty of the possible ways in which research into TYC students and classrooms could be framed and how it can impact a more diverse population of learners.

Finding TYC data is complicated by the fact that many TYCs now offer limited four-year degree programs. Even though the main mission of those institutions remains two-year terminal associate's or transfer programs, the Integrated Postsecondary Education Data System (IPEDS) now categorizes those community colleges as four-year institutions. This designation underestimates community college enrollments by 1.5-2 million students [7].

Data on TYC physics programs is particularly elusive. The American Institute of Physics' (AIP) Statistical Research division collects data about four-year college physics and graduate programs annually [8], but the last two AIP surveys of TYC physics programs and students were undertaken in 1996 [9] and 2011-2012 [10-11]. There is currently another survey in process, funded by OPTYCs, with the initial data release expected in 2025 [12]. The lack of current data leaves many questions about TYC physics programs yet to be answered, but we can get a (dated) snapshot of TYC physics students and programs from existing data.

A. Diversity of students at TYCs

Students at TYCs are generally more diverse than students at four-year colleges across multiple domains. (Fig. 1). The average age of community college students is higher [13], as is the number who have dependent children [14]. TYCs also have a greater percentage of women [15], first-generation students [16], veterans [17], and students with disabilities [18] than four-year colleges. Students there are far more likely to be part-time students, [13], and nationally one in five are dual enrollment high school students [19]. The percentage of full-time TYC students who were employed 20 or more hours a week is 47%, compared to 38% at FYCs [20].

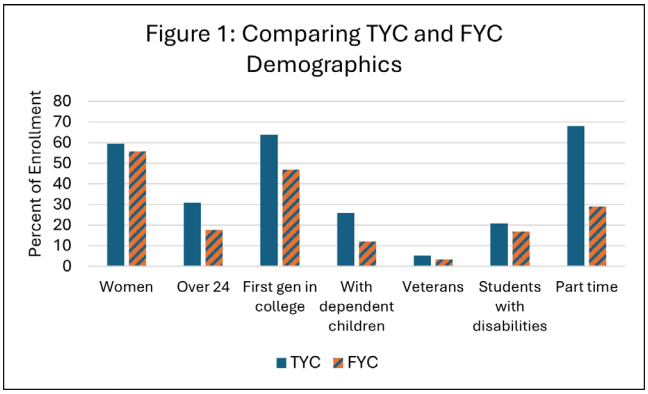

FIG. 1. Two-year college (TYC) students are more diverse than four-year college (FYC) students across multiple domains.

The National Center for Education Statistics shows that TYCs enroll more Black and Hispanic students than four-year institutions [21], while the percentage of enrollments of white and Asian students is higher at FYCs (Fig. 2). Enrollments of Native students are low in both types of institutions, but there are slightly more Native American students in TYCs.

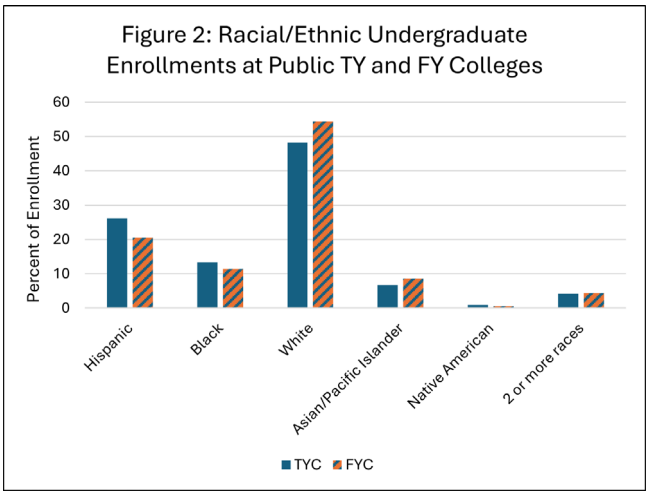

FIG. 2. Racial/ethnic undergraduate enrollments at public two-year and four-year colleges.

Students represented by most PER studies are enrolled in the calculus-based introductory course [1], while most students taking introductory physics at TYCs are enrolled in the algebra-based course (Fig. 3) [9]. In addition, a significant number of students at TYCs take conceptual physics. These students are most likely to be non-STEM majors, and conceptual physics may be one of the only science courses taken in their college careers. The National Science Board's Science and Engineering indicators show that in a survey of the general public's science factual knowledge, the average score was 63%, but when the questions were related to understanding the processes of scientific inquiry, scores dropped to 43% [22]. The conceptual physics courses offer an opportunity to physics faculty to expose students to the processes that lead to scientific knowledge and as a result affect the general public's understanding and trust of science. This also represents an opportunity for researchers to help better understand this student population and how best to support their understanding of science in the world.

The subjects of PER studies, primarily located at FYCs, include fewer underrepresented, ethnically diverse students than the general population of students enrolled in introductory physics courses [1]. As a result, the applicability of the results of those studies to more diverse student populations is not necessarily valid. Increasing TYC faculty involvement in PER could increase our overall understanding of physics teaching and learning, further help develop strategies that would better support all physics learners. Additionally, faculty at TYCs are in a unique position to support students from underrepresented groups in persisting in STEM fields by applying that knowledge directly.

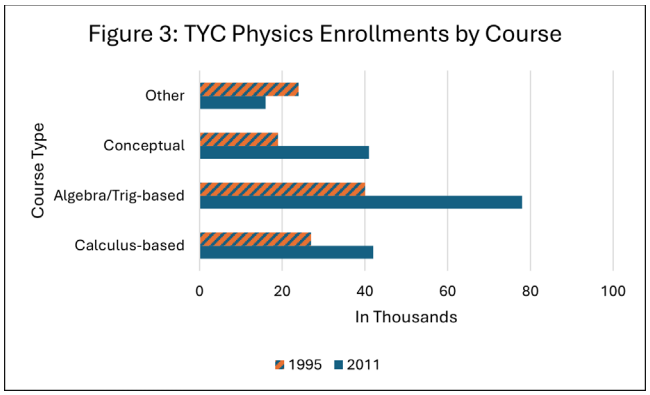

FIG. 3. Most TYC students taking introductory physics are enrolled in the algebra-based course (1996 and 2011 data, from [9]).

B. TYC students' voices should be heard

Students enrolled in physics courses in TYCs might also be facing additional challenges outside of the classroom that affect their academic engagement. While this is true for FYC students as well, the demographics of TYC students suggest that it is more likely for those students. TYC students might live with families that require care for the elderly or younger children, be working full-time or have one or more part-time jobs. Stable housing or consistent nutritional resources (i.e., dormitories and meal plans) are not usually available for these students. They are also more likely to be first-generation college students, who may not have generational knowledge of how to navigate the college experience. Because of the greater racial, as well as gender, diversity in TYCs, those in TYC physics programs are more likely to face systemic barriers in educational settings.

From an asset-based perspective, the challenges TYC students face push those students to develop skills that will support them through their college careers and beyond. Juggling college courses with outside responsibilities leads to improved competence in organization and prioritization and a keen sense of time limitations, which in turn helps develop efficiency, focus, persistence, and grit. The inequities that exist in educational settings are additional challenges that many of these students must face in their education. One initiative used to address inequities in STEM is the Underrepresentation Curriculum (URC) [23]. In a research study conducted by three TYC students and their mentor, Evans et al. (2019) compared two- and four-year college students' ideas about how to address inequities in STEM fields after participating in the URC [24]. They found that students in both settings responded with similar suggestions (e.g., the need to have intentional conversations about inequity and to understand personal biases). One significant difference between the two student groups was the "develop coping strategies" category. This suggested action, in which students described ways to respond to external pressures such as stereotype threat, microaggressions, and other expressions of bias, was

significantly more common at the TYC level. This is, perhaps, in response to the various challenges TYC students experience. For example, Sophia Herrera and Ikram Mohamed describe what they experienced in STEM classrooms and provide strong recommendations for steps that could be taken to start to change the culture of STEM academia and to support students from underrepresented groups [25]. The voices of TYC students matter, and as pointed out by Evans et al. (2019), their experiences highlight the need for educators and researchers to attend to the differences in student populations when applying curricula and designing studies. In addition, the greater diversity of TYC student populations as compared to average FYC populations provides opportunities for researchers to help illuminate the voices of those students from nondominant and marginalized populations.

III. TYC FACULTY

In this section, we share a few ways in which TYC faculty have different academic experiences from the typical FYC faculty, to provide background information to those interested in developing PER collaborations from FYCs. We acknowledge that some TYC faculty do PER, and some four-year college and/or university (FYC) faculty do not conduct research. Here we use the term "faculty" to refer to two-year and four-year faculty who are interested in collaborating in PER at TYCs.

The AIP survey of TYC physics programs from 1995-1996 reported that 44% of faculty teaching at TYCs held physics master's degrees, and 24% held physics PhDs [11]. A decade later it was reported that 51% of TYC faculty were in full-time positions, and 24% of them were women [10]. These are the most recent national demographic data available on TYC faculty who teach physics or astronomy courses; it is hoped that more current data will emerge from the AIP/OPTYCs survey.

A. Insights into TYC faculty doing PER

As current and former TYC faculty and active members of the TYC physics education community, we can provide some observational insights into that community. First, most TYC faculty are aware of the unique challenges faced by their students. Smaller class sizes enable faculty to develop strong working relationships with their students. Second, many TYC faculty have some knowledge of PER, and because they are frequently solo professors or members of small departments [10], they have flexibility to be innovative in their classrooms. Finally, although few TYC faculty are directly active in the PER community through carrying out and publishing formal research, many do research in their classrooms. Dean Stocker of UC Blue Ash, OH uses the Force Concept Inventory (FCI) [26] and student perceptions to assess the impacts of strategies he utilizes in his classroom. Elizabeth Schoene of South Seattle College, WA compares exam outcomes between different types of homework assignments, and Raeghan Graessle of Harper College, IL studies how communication affects student utilization of flexible deadlines. Finally, the third author (ARD) has published multiple articles in collaboration with TYC students [e.g., 23, 25, 27-29], and the first author (SLS) has studied ways to introduce physical science through high-interest current events [30]. This range of examples raises a question for the community as we look toward increased PER participation by/with TYCs: Where does the variety of scholarship on teaching and learning conducted at TYCs fall on the spectrum of PER?

B. Differences in load and institutional support

The average TYC teaching load is large, typically 15-18 contact hours per semester, and frequently increased by overload. Faculty at TYCs usually teach their own labs, and 50% have no staff assistance such as technicians for equipment maintenance and lab or demonstration setup [31]. There are typically no TAs, so all grading is done by the faculty. They serve as advisors, club coordinators, and must hold required tutoring and/or office hours ranging from 5 – 12 hours per week. Full-time faculty may also be responsible for supervising and mentoring part-time faculty.

Beyond the heavy teaching and service load, research is largely unsupported and undervalued at TYCs. If a TYC has a grants office, it is often minimal, and IRB processes may not be in place. TYC libraries have limited access to most research journals. While these factors make it difficult for TYC faculty to engage in independent formal research, many TYC faculty are interested in contributing to the physics education knowledge base. This suggests that meaningful partnerships that work within the constraints experienced by TYC faculty are one of the best ways to engage them in the PER community.

IV. DEVELOPING PARTNERSHIPS

At PERC '23 and '24, OPTYCs sponsored Conversation sessions, during which TYC and FYC faculty brainstormed ideas about how to initiate strong, equitable and productive TYC/PER partnerships [5-6]. The suggestions that emerged from those sessions form a possible foundation for creating productive partnerships, falling into three main overlapping themes: mutual respect, recognition of benefits and challenges, and logistics.

A. Mutual respect is critical to partnerships

De Leone et al. (2019) identified a need to explicitly develop mutual respect in partnerships between two-year and four-year colleges [32]. This need was reflected during the PERC sessions, appearing as one of the most common suggestions. Mutual respect could be fostered through the involvement of TYC faculty from the start of a proposed project, preferably by forming strong relationships prior to formal partnerships. One author (AE) noted that an effective

partnership he has experienced began with regular meetings, frequently over coffee or a meal, just to get to know each other and "talk shop."

Participants at the PERC '23 session noted that recognition of the expertise of TYC faculty can demonstrate respect, and that FYC faculty can frame themselves as partners, not "saviors." They suggested that FYC faculty get to know the personal insights, strengths, and resources that TYC faculty bring to a partnership rather than making assumptions about what they can (or cannot) contribute. TYC faculty do not want themselves or their students to simply be observed; they desire to be seen as valued collaborators and partners *to the extent that their expertise and teaching constraints allow.* Some TYC faculty may have the time and expertise to contribute in a substantial way to a project or may be interested in learning more about PER methodologies, while others might only want to serve in an advisory capacity. Participants at both PERC sessions emphasized the need for an awareness of each other's expectations, through conversations about the needs and constraints of both partners, with the collaboration made explicit in project proposals. The rules and guidelines that govern a partnership must be designed to fit the members of a proposed partnership and their institutions.

B. Recognize benefits and challenges

TYC faculty have expertise regarding the diverse student populations they serve, yet their voices are underrepresented outside of the TYC physics education community. Likewise, TYC faculty have insights on physics teaching and learning that may be missed in other contexts and could provide insight to help shape what a study on TYC or transfer students might look like.

Another benefit of an effective partnership is the possibility of TYC faculty members moving from "consumers" of PER-developed materials and strategies to developers or disseminators. Cochran et al. (2016) describe a long-term partnership, which includes one author (AE), in which TYC faculty started by self-identifying as purely consumers of professional development and curricular resources [33]. Some of the faculty involved ultimately changed their view to that of producer of resources, serving as workshop leaders and establishing learning assistant programs at their institutions. Providing effective partnerships with TYC faculty provides agency to those faculty, helping their voices, and those of their students, to contribute to the broader physics education community.

C. Logistics

Because TYC faculty may not have access to a grants office and the institution may not have an IRB process in place, it may fall to the four-year institution to carry out most of the administrative tasks. Moreover, TYC faculty may not have access to research journals, so providing collaborators access to the four-year college's library can provide better access to resources. TYC faculty should also be meaningfully compensated for their time. This might be as simple as a stipend, or as large as a summer salary or release time. TYC faculty may need to work with their administration to develop options for compensation including release time or stipend work.

V. DISCUSSION

Despite the significant proportion of students who take introductory physics at community colleges, that population of students has not been well-studied by the PER community. The development of research partnerships between two-year and four-year college faculty can give voice to both TYC faculty and students within the broader physics education community. Better understanding of TYC physics students and their educational experiences helps us better support a diverse student population.

Forming effective and equitable research partnerships is challenging, and there are multiple logistical problems to be solved. There is no one-size-fits-all set of guidelines for how to build partnerships. However, the primary component of a mutually beneficial partnership is respect, not only for the expertise and agency of the TYC faculty, but also for the expertise of the FYC faculty and the constraints under which both work. Despite these difficulties, forming TYC/PER/FYC partnerships can benefit the physics education community and larger physics field. The shared goal, for both faculty and researchers, is to learn and grow together so that all our students can thrive.

ACKNOWLEDGMENTS

We gratefully acknowledge the contributions of Vashti Sawtelle, Cami Monsalve and John Byrd at Michigan State University, who co-facilitated the Critical Conversation at PERC '23 and the Community Conversation at PERC '24. We also thank the participants in those Conversations who provided many of this paper's recommendations. We are grateful to Larissa Carter, Victor Marcos, and Chloe Elise Hennessy who provided insight for our Plenary presentation, particularly the student voices section. Dean Stocker of UC Blue Ash, OH, Elizabeth Schoene of South Seattle College, WA and Raeghan Graessle of Harper College, IL provided examples of the scholarship of teaching and learning. This material is based upon work partially supported by the National Science Foundation under Grant No. 2212807. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

[1] Stephen Kanim and Ximena C. Cid, (2020). Demographics of physics education research. Phys. Rev. Phys. Educ. Res.16.020106.
[2] U.S. Department of Education, Community Colleges. https://www2.ed.gov/about/offices/list/ovae/pi/cclo/index.html (2023) Accessed 10/18/2023.
[3] National Science Foundation, IUSE: Innovation in Two-Year College STEM Education. https://new.nsf.gov/funding/opportunities/iuse-innovation-two-year-college-stem-education (2023). Accessed 9/28/2023.
[4] The Organization for Physics at Two-Year Colleges, OPTYCs. https://optycs.aapt.org/ (2024). Accessed 7/19/2024.
[5] Kris Lui, Vashti Sawtelle, Abigail, Daane, Sherry Savrda, Karim Diff, and Camila Monsalves. Doing PER in Partnership with Two-Year Colleges. In Physics Education Research Conference Proceedings 2023. https://www.per-central.org/perc/2023/Detail.cfm?id=12141
[6] Kris Lui, Sherry Savrda, Vashti Sawtelle, and John Byrd, Initiating PER Collaborations with Two-Year Colleges. In PERC Abstracts 2024. https://www.per-central.org/perc/2024/Detail.cfm?id=16375
[7] John Fink and Davis Jenkins. Shifting Sectors: How a Commonly Used Federal Datapoint Undercounts Over a Million Community College Students, Community College Research Center. https://ccrc.tc.columbia.edu/easyblog/shifting-sectors-community-colleges-undercounting.html (2020). Downloaded September 13, 2023.
[8] American Institute of Physics Statistical Research Center, Results from the 2021 Survey of Enrollment and Degrees. https://www.aip.org/statistics/reports/roster-physics-departments-enrollment-and-degree-data-2021 (2022). Downloaded September 13, 2023.
[9] Michael Neuschatz, Geneva Blake, Julie Friesner and Mark McFarling. Physics in the Two-Year Colleges. American Institute of Physics Education and Employment Statistics Division. https://files.eric.ed.gov/fulltext/ED444642.pdf (1998). Downloaded August 24, 2023
[10] Susan White and Raymond Chu, Physics Enrollments at Two-Year Colleges: Results from the 2012 Survey of Physics in Two-Year Colleges. American Institute of Physics Statistical Research Center. .https://www.aip.org/statistics/reports/physics-enrollments-two-year-colleges (2013). Downloaded August 15, 2023.
[11] Susan White and Raymond Chu. Number of Physics Faculty in Two-Year Colleges: Results from the 2012 Survey of Physics in Two-Year Colleges. American Institute of Physics Statistical Research Center. https://www.aip.org/statistics/reports/number-physics-faculty-two-year-colleges (2013). Downloaded August 15, 2023.
[12] The Organization for Physics at Two-Year Colleges. Programs. https://optycs.aapt.org/programs/ (2023).
[13] National Center for Education Statistics, Digest of Education Statistics, Table 303.50. https://nces.ed.gov/programs/digest/d22/tables/dt22_303.50.asp?current=yes (2020). Accessed September 13, 2023.
[14] Institute for Women's Policy Research. Parents in College by the Numbers. https://iwpr.org/wp-content/uploads/2020/08/C481_Parents-in-College-By-the-Numbers-Aspen-Ascend-and-IWPR.pdf (2018). Downloaded September 28, 2023.
[15] National Center for Education Statistics, Digest of Education Statistics, Table 303.30. https://nces.ed.gov/programs/digest/d22/tables/dt22_303.30.asp?current=yes (2020). Accessed September 13, 2023.
[16] NASPA, Student Affairs Administrators in Higher Education First Generation College Students: Demographic Characteristics and Postsecondary Enrollment. https://firstgen.naspa.org/files/dmfile/FactSheet-01.pdf (2018). Downloaded September 28, 2023.
[17] Postsecondary National Policy Institute, Veteran Students in Higher Education. https://pnpi.org/wp-content/uploads/2022/11/VeteransFactSheet-Nov-2022.pdf (2022). Downloaded September 29, 2023.
[18] American Association of Community Colleges, Students with Disabilities. https://www.aacc.nche.edu/2018/09/26/datapoints-students-with-disabilities/ (2018). Downloaded September 29, 2023.
[19] John Fink, Community College Research Center, What Happened to Community College Enrollments During the First Years of the Pandemic? It Depends on the Students' Age. https://ccrc.tc.columbia.edu/easyblog/what-happened-to-community-college-enrollment-depends-students-age.html (2023). Accessed April 5, 2024.
[20] National Center for Education Statistics, College Student Employment. https://nces.ed.gov/programs/coe/indicator/ssa/college-student-employment (2022). Downloaded August 14, 2024.
[21] National Center for Education Statistics, Digest of Education Statistics, Table 306.20. https://nces.ed.gov/programs/digest/d22/tables/dt22_306.20.asp?current=yes (2022). Accessed September 28, 2023.
[22] National Science Foundation, National Science Board Science and Engineering Indicators, Public Knowledge about S&T. https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-technology-public-attitudes-and-understanding/public-knowledge-about-s-t (2018). Accessed September 28, 2023.
[23] The Underrepresentation Curriculum Project https://underrep.com/ Accessed June 24, 2024.
[24] Acacia Arielle Evans, Kai S. Bretl, Amad Ross, and Abigail R. Daane, (2019). Introductory physics students' insights for improving physics culture. In Physics Education Research Conference Proceedings 2019. 10.1119/perc.2019.pr.Arielle
[25] Sofia Herrera, Ikram A. Mohamed, and Abigail R. Daane, (2020). Physics from an Underrepresented Lens: What I Wish Others Knew. Phys. Teach. 58, 294-296. https://doi.org/10.1119/1.5145517
[26] David Hestenes, Malcolm Wells and Gregg Swackhamer, Force concept inventory. Phys.Teach. 30(3), 141 (1992). https://doi.org/10.1119/1.2343497
[27] Andrea Wooley, Randeep Basara, and Abigail R. Daane, (2021). Embracing subjectivity in physics to support student empowerment. In Physics Education Research Conference Proceedings 2021. https://doi.org/10.1119/perc.2021.pr.Wooley
[28] Delwrick Nanthou, Ahmed A. Gumale, Clausell Mathis, Michelle N. Brown and Abigail R. Daane, Grappling with the dominant narrative of physics: Instructors rethink colonial roots together to shape classrooms. In Physics Education Research Conference Proceedings 2023. http://doi.org/10.1119/perc.2023.pr.Nanthou

[29] Larissa J.G. Carter, Victor Marcos, Chloe Elise Hennessy, Andrea Wooley and Abigail R. Daane, Students attribute myriad cultural factors to their sense of physics. In Physics Education Research Conference Abstracts 2024. https://www.per-central.org/perc/2024/Detail.cfm?id=16530
[30] Sherry L. Savrda, Developing a Physical Science Course Focused on Sustainability. The Physics Teacher, 61(7), 611-913 (2023). https://doi.org/10.1119/5.0141600
[31] Raymond Chu, From the OPTYTs/AIP survey of TYCs, Part 1. Personal conversation, July 26, 2024.
[32] Charles J. De Leone, Edward Price, Mel S. Sabella and Andrea G. Van Duzor, Developing and Sustaining Faculty-Driven, Curriculum-Centered Partnerships Between Two-Year Colleges and Four-Year Institutions. J. Coll. Sci. Teach. 48(6), 20-27 (2019).
[33] Geraldine L. Cochran, Andrea G. Van Duzor, Mel S. Sabella and Brian Geiss. Engaging in self-study to support collaboration between two-year colleges and universities. In Physics Education Research Conference Proceedings 2016. 10.1119/perc.2016.pr.014