Forum on Education
American Physical Society

Summer 2019 Newsletter

Jennifer Docktor, Editor

In This Issue:

From the Chair

Laurie McNeil, University of North Carolina at Chapel Hill

As the 2019 Chair of the Forum on Education (FEd), I would like to bring you up to date on the current activities of the Forum. Our revised bylaws shifted the terms of office for Executive Committee members such that their terms now begin and end with the calendar year rather than with the annual meeting of the committee (which usually takes place in April). As noted in the Spring 2019 newsletter, on January 1, 2019 we welcomed three new members of the Executive Committee (including our first-ever graduate student member). These new members participated in the committee's annual meeting on April 15. Also on January 1 the members of the Chair line shifted to their new positions and began their new tasks for the Forum.

As the new Vice-Chair, Catherine Crouch has formed the Nominating Committee to solicit nominations for new Executive Committee members who will take office next January; please see her call for nominations below. Jerry Feldman, the new Chair-Elect, is charged with serving as the Forum's Program Chair for the 2020 March and April meetings as well as with organizing a plenary session the 2020 Summer Meeting of the American Association of Physics Teachers (AAPT) and assisting with the planning of an education-related session at the 2020 meeting of the APS Division of Atomic, Molecular, and Optical Physics (DAMOP). If you have ideas for invited session themes or speakers for any of those meetings, please get in touch with Jerry. His Program Committee is already at work on next year's offerings.

The sessions organized by the Forum reach the many APS members who attend the March and April meetings, but this is only a subset of the membership (albeit a large subset, over 20%, at the March meeting!). Many other members are more likely to attend meetings of an APS Division, Topical Group, or regional Section. If you are involved in the planning for any of these meetings, I urge you to consider organizing an education-related session. Education is a concern for APS members across all research fields and geographic areas, and it deserves representation in all our scientific meetings. If you want to consult with the leadership of the Forum for suggestions about organizing such a session, please feel free to contact us.

The March and April meetings this year were well attended and very successful. The Forum presented five invited sessions at the March meeting (some jointly sponsored by other units including the Forum on Industrial and Applied Physics, the Forum on Graduate Student Affairs, and the Division of Condensed Matter Physics). The invited speakers addressed a variety of topics including teacher education, teaching biology to physicists (and vice versa), advanced laboratory instruction, and careers in physics. There was also a contributed session with presentations on a range of physics education topics. At the April meeting the Forum organized five invited sessions and one contributed session. Two of the invited sessions were co-sponsored by the Topical Group on Physics Education Research (GPER) and one by the Division of Computational Physics (DCOMP). Topics addressed by the speakers included lab courses, quantitative methods in physics education research, teaching energy, introducing computation into physics courses, and stereotype threat. FEd Program Chair Jerry Feldman welcomes your suggestions for sessions for the 2020 March meeting in Denver and the 2020 April meeting in Washington DC. Please see his call for suggested sessions below. At both the March and April meetings the Forum co-hosts the Education and Diversity Reception jointly with the APS Office of Education and Diversity, the Committee on Minorities (COM), and the Committee on the Status of Women in Physics (CSWP). As usual, attendance was excellent at both meetings as APS members interested in improvements in education and diversity gathered to celebrate the year's successes.

Although it is now past the deadline for submitting nominations for APS Awards and Fellowships for the current year, I want to encourage you to think about nominating persons (or groups) for these honors for next year. Specifically, please consider the Excellence in Physics Education Award — to recognize and honor a team or group of individuals (such as a collaboration) or, exceptionally, a single individual, who have exhibited a sustained commitment to excellence in physics education; the Jonathan F. Reichert and Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction — to recognize and honor outstanding achievement in teaching, sustaining (for at least four years), and enhancing an advanced undergraduate laboratory course or courses at US institutions; and the Award for Improving Undergraduate Physics Education — to recognize physics departments and/or undergraduate-serving programs in physics that support best practices in education at the undergraduate level. I also ask that you think about individuals who are deserving of an APS Forum on Education Fellowship — to recognize exceptional contributions to the physics enterprise; e.g., outstanding physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education. Fellowship is a distinct honor signifying recognition by one's professional peers. We all know of deserving colleagues for these awards and for fellowship, but we must nominate them for them to be considered. Please consider putting in the effort to do so.

FEd also works closely with the APS Committee on Education (COE). The past chair, chair and chair-elect of FEd are also members of the COE. In this way, the Forum maintains an active voice in physics education in the American Physical Society. Topics considered by COE this year include a proposed APS Statement on the role of the Physics Graduate Record Exam (PGRE) in admission to graduate programs in physics and the Effective Practices for Physics Programs (EP3) project.

We can be successful only by having an engaged membership in the Forum. Please contact me or any member of the Executive Committee with suggestions or contributions toward our educational mission. We look forward to hearing from you, and to seeing you at Forum events.

Call for Nominations for the FEd Executive Committee

Catherine Crouch, Swarthmore College

Four new members of the Forum on Education Executive Committee will be elected in the fall to take office in January 2020: the Secretary-Treasurer (3-year term), one of the joint APS-AAPT members (3-year term), one of the Members-at-Large (3-year term), and the new Vice-Chair. The Vice-Chair serves in a four-year Chair succession line with different responsibilities each year.

The FEd Executive Committee plans education-related sessions at APS meetings, nominates new APS Fellows, and presents FEd awards. They represent the goals and concerns of the FEd membership to the APS Council of Representatives. Serving as a FEd officer is also an excellent way to learn about APS and its various educational missions and to influence science education at the national level.

Please send suggestions nominating yourself or a colleague to:

Catherine Crouch (ccrouch1@swarthmore.edu)
FEd Vice Chair and Chair of the Nominating Committee
Department of Physics & Astronomy, Swarthmore College

Nominations must be received by July 8 for full consideration although nominations received later will be given whatever consideration is still possible. (New officers are elected every year, so even if your nomination is too late for this year, it can be considered for the following year.) The nominating committee will consider all nominees and assemble a ballot.

Serving a diverse and inclusive community of physicists worldwide is a primary goal for APS. Nominations of women, members of underrepresented minority groups, and scientists from outside the United States are especially encouraged. We are looking forward to receiving your nominations.

Request for Session Topic Ideas for Upcoming APS Meetings

Jerry Feldman, George Washington University

Each year the Chair-elect of the Forum on Education is also the chair of the FEd Program Committee. The Committee organizes invited sessions at the American Physical Society's March and April meetings. The Forum is allocated a number of invited sessions at each meeting, a number that can be increased by co-sponsoring sessions with other units such as the Forum on Outreach and Engaging the Public (FOEP), the Topical Group on Physics Education Research (GPER), the Forum on Physics and Society (FPS), or one of the scientific Divisions such as the Division of Atomic, Molecular, and Optical Physics (DAMOP). The Program Committee works with the AAPT to sponsor two April meeting sessions and with GPER to sponsor one April meeting session; there is an additional April session on an education topic chosen by the Program Committee.

We are always looking for ideas for session topics (and potential invited speakers) that would be interesting and beneficial to the members of the American Physical Society whether or not they are members of FEd, since education in physics affects us all. If you have ideas that you think would make good invited session topics at one or the other of these two meetings, please send them to Jerry Feldman (feldman@gwu.edu). Any ideas submitted will be considered by the Program Committee this year, and if not implemented will be passed on to future program committees for their use.

FEd also sponsors contributed sessions at both these meetings at which are presented papers that are contributed in the Physics Education sorting categories. I invite you to consider contributing an education paper to one of these two meetings.

From the Editor

Jennifer Docktor, University of Wisconsin – La Crosse

I'm excited to introduce myself as the new editor of the Forum on Education Newsletter, and I would also like to take this opportunity to thank Richard Steinberg for his service and mentorship. For my first issue, I've chosen a topic near and dear to my own experience – Women in Physics. At least that was my initial choice of a theme! As you'll see when reading the contributed articles, the concerns about representation in physics are broader than just focusing on women – as a community we need to welcome a variety of gendered and racial identities (and multiple minority identities). This newsletter summarizes some of the issues we still face as a field and highlights one program to support K-12 teachers to reduce barriers in Physics called STEP UP.

I hope this newsletter inspires you to reflect on the role you play in promoting a culture that values diversity and inclusion. If you have ideas for future newsletter themes or an article you would like to contribute, please e-mail me at jdocktor@uwlax.edu.

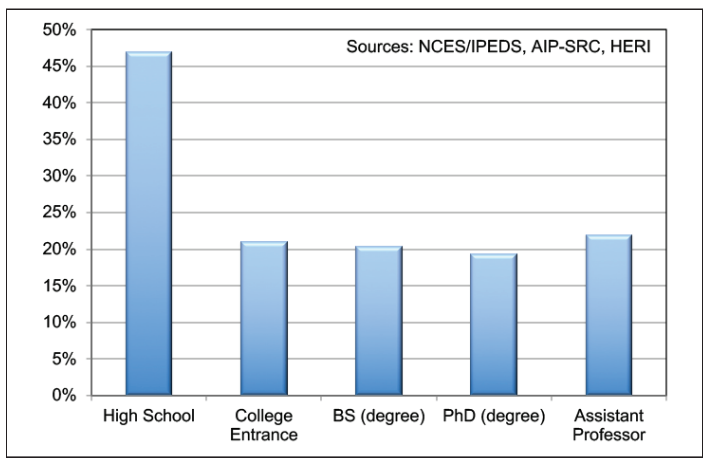
Director's Corner: Do you know a teacher?

Theodore Hodapp

Women continue to be significantly underrepresented in physics. Despite slow gains over the past 50 years, we still only see a roughly 20% participation rate at the undergraduate, graduate, and entry-level academic positions. As a community, we have worked to address this in many ways, and yet we are stilling falling short. We have come to understand that efforts at the post-secondary level will not be sufficient to address this issue.

Women face a multitude of messages starting from birth that integrate into an ever-present undercurrent of discouragement for their participation in certain areas – physics is one of those areas. Overcoming this can be daunting for a community dedicated to equity.

Daunting, however, does not mean impossible. John F. Kennedy said, *We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard*. We are taking his advice: we need to try the "hard" things to overcome a serious challenge and one reason the APS has decided to venture into a territory that we don't typically inhabit: high school classrooms.



Fraction of women participating in physics at various stages

The STEP UP project, beginning its third year, recognizes the significant impact we can have on women's participation in physics by enlisting high school physics teachers to give lessons in careers and underrepresentation – two topics that have been shown to impact women's persistence to majoring in physics as an undergraduate. Our first two years have been absorbed in developing and testing, in a controlled study, the effectiveness of these interventions. I am happy to report that we have seen a substantive effect. Our next step is to invite teachers to share these lessons with their students. This will begin the important work that cannot be accomplished in other settings: attracting substantially more women to join the community – women who would have otherwise turned away from further studies in physics.

This next year is key. We need to recruit thousands of teachers to join this movement. We have recruited a large cadre of master teachers and teacher leaders to help with this, but we can use your help in further recruitment efforts. Do you know a local high school teacher? Can you talk with them and ask them to join in this movement? Would you be willing to reach out to teachers in your area on behalf of this important mission? APS has materials to support your outreach, including talking points, promotional materials and email templates as well as links to download the free curriculum. We need everyone's help reaching teachers so they can use these research-proven materials and have a significant impact in changing the fraction of women pursuing physics. Please visit STEPUPphysics.org to learn more about how we can work together to meet this challenge or reach out through this form to request outreach materials.

Gender and Physics: An Evolving Field

Laura McCullough, University of Wisconsin-Stout

There have been an increasingly large number of articles in the news about various aspects of gender and STEM. Where are we at with this issue for our field of physics?

"Why do we need to keep studying this issue; haven't we solved it already?"

Yes, it's been three decades since the Chilly Climate report came out [1]. And no, we haven't solved it. In the US, we've stalled out at 20% of physics degrees earned by women, and that's at every level [2]. This problem is far from solved.

"You have it so easy these days; I had to fight for everything I got."

Just as PER has evolved from figuring out student "mis"conceptions to exploring the effects of the classroom to the current breadth of what PER people are studying, the research on women in physics has changed and grown. From simply determining participation rates to exposing explicit harassment and discrimination to learning about implicit bias, we continue to explore what is preventing women and gender minorities from entering into and staying in physics. This is made more complex because the target is constantly shifting: what a female physics professor dealt with in 1990 is not the same as what a newly minted PhD will encounter next week. As our culture changes while maintaining a disturbingly robust gender gap, our research has to adapt to the new circumstances. And our interventions need to change as well. The early support programs to promote women's participation in STEM focused on fixing the women—assuming the problem must be with them. Research has shown the problem is much more about the culture, and this is harder to change.

"You teach physics? You must be smart!"

How many of us have heard this—and cringed? As teachers, we need to understand that every student can learn physics. And we hope our students will believe they can learn it too. This is part of a growth mindset, where we know we can improve our skills and even our character traits. This is in contrast to the limitations that come with a fixed mindset, where a person believes their intelligence and abilities are set in stone—we are born at a certain level and we can't be changed.

Why should we, as teachers interested in gender and science, care about mindset? We know that students with growth mindsets do better in school [3] and that there is a gender-related effect. A growth mindset in math helps women more than it helps men [4]. Consider this statement: "Girls can't do physics." This is a classic fixed mindset statement and one we should endeavor to change. By promoting growth mindsets, we are not only helping students do better individually, but we will be helping change our cultural mindset too. This is especially important for our trans colleagues; we *can* change ourselves and *everyone* can learn physics.

"Ben Barres gave a great seminar today, but then his work is much better than his sister's." [5]

One of the changes I have seen in 20 years of doing work on this area has had a subtle effect: I no longer say I study women and physics; I study gender and physics. As our world becomes more aware of the range of gender expression and as the strictness of gender roles relaxes, we need to make changes in our own language and our work. Along with this is one of the most important developments in gender research: intersectionality. Instead of assuming all women behave the same way and all women experience physics the same way, researchers are recognizing the importance of the multiple identities every person contains. A black woman in rural Wisconsin and a Latina in Texas will not have the same encounters with physics, and to lump them together because they are both women loses an important part of the experience. A trans woman and a cis woman can be exactly the same on other identities, yet their interaction with physics will be different. Our research has to take this into account. We have to understand all the ways that physics and gender interact and how that can discourage different people from participating in different ways.

"I never was any good at physics."

Current research on where girls and young women lose interest or drop out of physics shows that it happens everywhere and for a variety of reasons. A female elementary teacher afraid of science passes on that fear to her female pupils. Parents don't think about taking their daughter to a science museum. Middle school girls start believing that you can't be cute AND smart. High school girls are encouraged away from science majors through implicit or explicit bias. A freshman is the only young woman in her physics class. A grad advisor tells her female grad students to put off getting pregnant. Hiring committees unconsciously rate a female applicant lower. Stopping the tenure clock is counted against an assistant professor. Fewer grants and more service mean a longer time as associate professor. A lab manager doesn't get the same level of resources as her male colleague. The "problem" of women and physics is not women or physics or just one problem, but a broader culture that tells us from a very young age that physics is a man's field.

"How do you change culture? Where would we even start?"

We need to be supporting research and the interventions it identifies as useful at every age and level. We need better science classes for elementary teachers, we need high school curricula about the under-representation of women and minorities in physics [6], we need better college physics education, and conferences for undergraduate physics women [7]. We need family-friendly policies that everyone is encouraged to use, we need people to understand cultural effects and implicit bias. We need to figure out how to support girls and women at every stage. We need to find all the points of friction between success in physics and identities outside of white male and smooth out the bumps so that everyone can participate in and advance the study of physics.

Why? Because if we fail in supporting every person of any gender, physics is losing out on unknown amounts of talent. How many brilliant ideas have been lost or delayed because a young woman was not welcomed into physics? To make physics the best it can be, we can't turn away any interested people. And to change this, we need to change our culture.

So read those articles, learn from them, and share them with your colleagues; the issue of supporting everyone in physics is something that we all can work on.

Laura McCullough is a Professor in the Department of Chemistry and Physics at the University of Wisconsin – Stout. Her primary research area is gender in science and surrounding issues, and she authored the 2016 book "Women and Physics", a Morgan & Claypool publication as part of IOP Concise Physics.

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Physics Together: Engaging Young Women in Physics with STEP UP

Robynne Lock, Texas A&M University - Commerce

Only one-fifth of physics bachelor's degrees in the US are awarded to women annually, and the representation of women in physics and most STEM fields at the undergraduate level has not increased for the past 10 years. Therefore, new efforts are needed to engage women in physics. Supporting women in physics is important not only for the sake of equality but to ensure the future of physics. Physics majors constitute a small minority of STEM majors. Biology and engineering each graduate approximate 100,000 majors per year, but physics only graduates 8,000. If women do not feel welcome or supported in physics, we are missing half of potential future physicists thus limiting the talent pool and the diversity of ideas brought into physics. STEP UP, an NSF-funded partnership between Florida International University, Texas A&M University-Commerce, AAPT, and APS, is a national initiative with the goal of encouraging more women to pursue physics bachelor's degrees.

We focus our efforts on supporting high school teachers in encouraging young women in their physics classes. High school is often the first time students learn about physics as a distinct science and is also our last chance to engage many students in physics, as the majority of college majors do not require physics. Fortunately, nearly half of all high school physics students are young women. The fact that the representation of women in physics from college entrance through to the assistant professor level is approximately constant underscores the importance of intervening during high school. This is in contrast to biology and chemistry in which the percentage of women drops at each academic stage. High school teachers can be instrumental in encouraging their students to become physics majors. Class sizes tend to be smaller and contact time longer in a high school class compared to a college class, thus allowing teachers to build strong connections with their students. High school teacher encouragement to pursue physics can make the difference.

Women are outnumbered by men in physics five to one in the US for a myriad of reasons, not all of them well understood. Some might claim that women are simply not interested in physics. However, interests are shaped by society and culture. This is borne out by the range of representation of women in physics in different countries. For example, 60% of physics majors in Iran are women. Additionally, though young women and men perform equally well in high school physics, women tend to perceive physics as difficult and underestimate their own abilities. This may result in fewer women pursuing physics degrees. Leslie et al. found that the more difficult a field is perceived to be, the fewer women earn Ph.D.'s in that field.[1] This low interest and low self-confidence are instilled by society from a young age and must be actively counteracted. Finally, the general public does not understand what physicists actually do and what can be achieved with a bachelor's degree in physics. Physics contributes a great deal to society and improving the world. Many students want to do so in their careers, but do not know that physics opens that door.

STEP UP seeks to engage high school teachers in empowering the young women in their physics classes. This means discussing the influence of society and culture on students' career decisions and also informing students of career opportunities available to physics graduates. Two lessons grounded in research have been created along with an Everyday Actions Guide. The Women in Physics lesson focuses on discussions on the current status of women in physics, unconscious bias, and students' personal experience with bias. The goal of the lesson is to make young women aware of the societal and cultural influences on their interests, confidence, and career decisions so that they can consciously counteract them. The Careers in Physics lesson illustrates the variety of careers that are achievable with a physics bachelor's degree. Students read and discuss profiles of modern day physicists whose careers align with their own interests. Most importantly, students create profiles for their future selves in which they used a physics degree to achieve their career goals. Careers in this lesson include medical physicist, prototype engineer, and financial analyst. Initial results indicate that these lessons are successful in helping students to see physics in their future and improving students' recognition as physics people.[2] Building recognition as a physics person is extremely important to recruiting students, especially women, into physics.

STEP UP is moving forwards in bringing as many high school teachers into the movement as possible. Our ambassador program empowers high school teachers to become leaders in their communities. University faculty can contribute to the movement by sharing information about STEP UP with local teachers and teacher networks and integrating the materials into their physics teacher preparation programs. Additionally, the lessons can be adapted for use in introductory college physics courses. Undergraduate and graduate students can support the movement by conducting outreach with local high school teachers. The power to energize the future of physics lies with high school physics teachers, and STEP UP provides teachers with the tools they need. Join the movement to engage thousands of high school teachers in this effort. Together we can change the face of physics.

To learn more about STEP UP and become a member, go to STEPUPphysics.org.

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Robynne Lock is an Assistant Professor in the Department of Physics & Astronomy at Texas A&M University-Commerce. She researches physics identity, strategies to recruit students into physics, and gender. She is a 2017-2019 PhysTEC Fellow.

Implementing STEP UP in an Inner City School

Jolene Johnson, Edison High School, Minneapolis, Minnesota

As a female I went through my entire physics education career never having a female physics teacher or professor. My classes never seemed to have more than a handful of women, and often I was the only woman in the class or research meeting. My interest broadened beyond gender issues as I continued my schooling and saw the struggles that minority groups experienced in physics. I also became active in social justice issues, especially in my neighborhood of North Minneapolis which is historically the most diverse part of Minnesota. Therefore, when I heard about the STEP UP program at an AAPT meeting, I knew I wanted to be a part of it. The launch of the program also corresponded with my switch to teaching high school physics after 6 years of teaching college physics at St. Catherine University (an all-women's college). A large part of my decision to switch to teaching high school was because I see high school as the best chance to influence a diverse group of students to consider physics. Research backs me up on this and it is part of what STEP UP is built on. I tell you all this because when I thought about how to implement these materials in my classroom, it was through the lens not only of my students, but also through my experience in physics.

STEP UP is an APS/AAPT joint venture with a goal of doubling the number of female physics majors by focusing on a few key lessons in high school physics courses. Here I am going to focus on the specifics of the lessons, how I implemented this in my diverse classroom, the student and teacher reaction to the lessons, and ideas for future work and improvement. I implemented these lessons in all my physics classrooms. This summer, I am a STEP UP ambassador and I look forward to meeting other ambassadors and further training at a workshop in Provo, UT.

About my students and my school

I teach at Edison High School in Northeast Minneapolis. Edison is a public neighborhood school that reflects the diversity of the inner city. 85% of our students qualify for free or reduced lunch (a measure of family income), and more than 85% of our students are minorities. We also have a large population of immigrants from all over the world including Somalia, Mexico, and Ecuador. Physics is taken in either 11th or 12th grade in our school and taking either physics or chemistry is a graduation requirement in Minnesota. Because of decisions about scheduling, my physics classrooms typically contain an even higher percentage of minority students and ELL students than the overall school population. Minnesota has one of the largest achievement gaps in the country and our school's test scores reflect that gap. Our students tend to score relatively low in math, reading, and average ACT scores. This showed up in my physics classroom as I had to teach everything from number lines through trigonometry to help students be successful in physics. I used the lessons in four sections of regular physics (class size 25-35) and two sections of IB physics (class size 8-14). In two of the regular physics classes, I have an ELL co-teacher. At Edison about 40% of students are interested in a career in engineering or related fields based on student interest surveys. However, the population of students who leave ready to enter a 4-year college with a STEM career is relatively low.

Introducing the STEP UP materials

The STEP UP materials are free to download aps.org/programs/education/su4w/index.cfm. Especially as a first year high school teacher, I found them to be wonderful! They contain everything you need including the lesson plans, materials, PowerPoints, and background information. To get the materials you just need to sign up and then you will get a link. STEP UP really consists of two units: One on careers in physics and one on women in physics. The careers unit starts by having students think about what careers physicists do. Then the students are matched with a career profile of someone who majored in physics based on their interests. The students research this career and share what they learned. Then as a class, we go over some statistics and facts about how physics in useful in a variety of careers. Finally, the culmination is having the students write their own career profile. The students pretend they majored in physics and then write about how they use physics in the career of their choosing. As much as possible, I encouraged students to pick the actual career they are interested in to make it more personal.

The second lesson is about issues facing women in physics. The lesson opens with students doing a google search of famous physicists. If you haven't done this, I encourage you do it. One of the key takeaways is that there is a long list of physicists but all except 1-2 are males, all except 2-4 are white, and most are long dead. Next, the students read short biographies of famous female physicists who have had their work overlooked, along with other current not-so-famous female physicists. The students reflect on the science the women discovered and their experience as a female in physics. Next, as a class we go through the statistics of women in physics for the US and other countries. Possible ideas for why women are underrepresented in physics are presented along with some research behind the ideas. Ideas like stereotype threat and unconscious bias are presented. Finally, the students reflect on their own experiences including what type of career they are interested in. The final reflection is an essay on why the students think women don't go into physics and if society's expectations have influenced their career decisions. This lesson originally had more elements of other types of diversity in physics. In the current version the lesson was tightened to focus on women in physics, but I made the decision to add more data and discussion on racial diversity and the intersection of race and gender (more on this later).

Implementation in our classroom

As stated, my classes contained 25-35 diverse students. Our classroom focuses on group problem solving from day 1. The students are set up in assigned groups of 3 and 6 students. The groups rotate about once per month and the groups are designed to be diverse in all ways including student academic strength. We used these same group structures to help us with discussions during both units. In our class, we made the decision to do the careers unit in early November at the start of our second quarter. Before this, we had built a classroom community by doing student information surveys, having the students write and share a "My STEM story" essay and focused on group problem solving skills. The lesson as designed is supposed to be 60-90 minutes plus homework. In our class, we spread the lesson out over four 44-minute periods. We did the women in physics unit in late March at the end of quarter 3 for regular physics, and in early June for IB physics. The timing was partly because of spacing of content, and partly based on having a well-established classroom community before looking at difficult issues. The women in physics unit was designed for 60-90 minutes. In our classroom, we spent three 44 min class periods in regular physics and two 44-minute classes plus significant homework for IB physics.

Reaction of students and school community

Overall, the students were very engaged in these lessons; they reported they enjoyed the lessons; and felt the lessons were some of the most valuable things we did all year. In end of year surveys students consistently said both lessons were their favorite units of the year and that the units helped them see the connection of what they were learning to their everyday life.

Reflection: Careers unit

As someone who came from a college setting with a focus on career readiness, I was very surprised to learn that most of my students had given very little thought to their future career options before we did the careers unit. Most students had a very limited knowledge of what a physicist or STEM major did for a job. It was in this unit I realized I needed to define STEM, because more than half my students did not have any idea what STEM stood for. Before the unit, most students thought physicists either did research in a big lab or were teachers or professors. As we went through the unit and read all the different career profiles, the students were genuinely surprised at the wide range of careers and job titles that physicists had. Based on post unit surveys there was an increase in the number of students who were interested in physics majors and physics careers. The biggest interests were in areas related to medicine and biomedical engineering jobs. As Minnesota is known for its medical device industry, if this unit was fully implemented in all Minnesota high schools, it could help our state diversify that important workforce. The students were very interested in most of the career data, especially about MCAT and LSAT scores by major. At least 75% of the students had never heard of these tests before, but once they realized the tests were important for doctors and lawyers they were interested in ways they could improve their scores. There was a robust discussion of why physicists do so well. This discussion helped me connect the critical thinking and problem solving skills I have been trying to teach them to actual useful skills in a wide range of careers.

The career profile was highly engaging for the students and really helped them see themselves as physicists, STEM career professionals, and as scholars with specific career goals. Students wrote about a wide range of careers. They used the career profiles they read as inspiration, but also applied them to their own lives and goals. Many of the students wrote about medical careers and engineering careers. After writing the profiles, the students had to make another list of physics careers and sort them by general areas. This class map contained a lot more areas and a lot more careers in each area. The biggest increases were in medicine and humanities careers (like science writing).

The impact of this unit continued well past the single week we spent on the unit. I became an informal college mentor to many students interested in physics and engineering. During college application and selection process, I met with many students with potential interest in physics and engineering. We discussed things like which colleges would be a good fit for their majors, possible scholarships, and even selecting classes by the end of the year. Since the vast majority of my students will become first generation college students, having this connection was very useful to them. They asked questions from "what is a major?" to "how does taking 4 classes actually count a full time?" I had at least 10 students (all students of color, half women) who expressed strong interest in majoring in physics or engineering at a 4-year college. I also talked with another 5-10 students about options for starting at local community college programs with engineering pathways. I know some of these students did not have engineering on their radar before this unit. While the goal of the program is to increase the number of physics majors, I can see a huge bonus benefit is the increase in the diversity of students considering STEM majors like engineering. The students continued to make the connection of what we were learning in class to their potential careers and majors. Students requested that we cover things like fluids and other physics topics they saw as possibly relevant to their future goals. While I was not able to cover all the topics the students expressed interest in, they gave me many ideas for future topics to cover in the various physics courses.

Reflection: Women in physics/diversity unit

While the students responded well to both units, they listed the diversity unit as their favorite. Since I expanded the women in physics unit to include diversity, the students felt a specific connection to the information being presented. In all my classes, I only had about five white male students and even those students saw some of their struggles reflected in the information presented in the lesson (like low income or first generation college student status). In end of year and unit surveys students said that it helped and they had better understanding about why I care so much about helping them learn and appreciate physics. Hearing my background and my articulation of why diversity in physics really matters gave students more insight into who I am as a teacher and person. This made them more open to having discussions with me about all sorts of topics. When the statistics on the lack of diversity and women in physics was presented students fell into two camps. I would estimate about three-quarters of them were very surprised to learn that there are entire career fields that are still so segregated by gender and race. The other quarter of the students had some information on the lack of diversity but they had not done much thinking about why this was. When I first asked them for possible reasons to explain the lack of diversity, they struggled to come up with reasonable answers. After our class discussion of some of the psychological factors such as implicit bias and stereotype threat, the students made their own list of 20 possible factors that lead to the low diversity in physics. I was happy to report to the students that many of the ideas they came up with were things that researchers were looking into. This discussion was also another sneaky way to get students thinking like scientists. They were coming up with hypotheses based on the data presented. Some of them were so excited to see if their ideas were right that they went to google to see if their ideas had been studied and what sort of data there was. There was one female African immigrant in particular that became so interested in this subject that I will be working with her on her personal IB project to explore the research of why women don't pick physics majors. Many other students were very interested in this type of research and asked what path they could take so they could do these types of studies in the future. Other students applied what they were doing to our own particular school and asked some very pointed questions about why our school lacked the supplies and support that the richer whiter school districts had. This conversation in particular was exciting to me because my goal as a teacher is to empower students to force change in systems that have traditionally excluded them (including physics). I know as one female physicist I cannot change the culture in physics, but my hope is that I can make a bigger difference through widening the types of students who enter the physics community.

In addition to student feedback, I also got feedback from my teacher mentor and principal who both observed a day of each lesson. The feedback was overwhelmingly positive. They appreciated the lesson structures and relevance to our diverse population. They also liked how students seemed to claim ownership of the material by the end of the unit. My mentor asked me to share this information with other science teachers in the district (which is my plan as an ambassador!) My principal encouraged me to have discussions with other science department teachers as to how they could add something similar to their classes.

Looking to the future

Having completed my first year in a high school classroom, I am now focused on how to leverage this unit the student response to improve more areas of my class and student engagement. Next year I am hoping to set up at least one company field trip shortly after the careers unit so the students can meet real physicists and engineers. I am hoping to visit Medtronic, 3M, or one of the other great STEM companies we have in Minnesota. I closed the year by having students watch Hidden Figures and a documentary called Jim Crow of the North, which focuses on how housing discrimination shaped race relations in Minneapolis. I realized that having these movies closer to the diversity/women in physics unit would lead to discussions that are even more fruitful. Next year, I hope to extend the entire unit to about 2 weeks total and have the students write reflections that are more extensive on how society had shaped their career choices. In surveys, students also requested to learn more about diverse physicists, so I plan to add that in, hopefully at least one diverse physicists focus per physics unit.

Final thoughts

If you are at all on the fence about implementing these lessons in your classroom, I encourage you to try it. I think with some adaptation, these lessons could be used for anything from 9th grade through even upper level college courses. You might be thinking "I already have way too much physics to cover, how can I take a day or week away from that?". First, I encourage you to think about the potential impact on your students. Very few physics units are going to give students a completely new way of seeing themselves the way that these units can. The careers unit can be leveraged to get more student buy in to wide range of physics topics. The diversity unit helps students see that you do care about more than cramming physics knowledge into their heads. If you would like more training or want to talk to someone who has done the units any of the STEP UP ambassadors would be glad to help. You can find our information here.

Jolene Johnson teaches Physics at Edison High School in Minneapolis, Minnesota and is an ambassador for the STEP UP program. She received her BA in honors physics from Gustavus Adolphus College, and a MS and PhD in physics from University of Minnesota. She taught at St. Catherine University for 6 years before switching to teaching high school in the 2018-2019 academic year.

Reflections on STEP UP from an EL Teacher

Billy Menz, Edison High School, Minneapolis, Minnesota

The women in Physics and diversity units are essential for overall success in an urban school and I would argue also provide great value in schools that lack diversity. For us at Edison, the diversity unit was the most powerful teaching in Physics we had all year. The unit discusses and highlights (or lowlights) the selectivity that the sciences have had in the past regarding students of color and women. Introducing young women and students of color to the facts about Physics careers and challenging them to fight against those stereotypes not only helps them achieve in the Physics classroom but also puts a social justice lens on Physics education. Most students see that women are not in Physics and people of color are not well-represented in science careers but they don't understand why or how to change it.

Change and action motivates students. Students at the high school level are very hesitant to take risks outside of how they identify socially, academically and culturally. Many students of color, ELs or female students don't see themselves as Physicists or scientists and our students at Edison were no different. However, by explicitly teaching them that this may not be due to their interests, but rather due to social injustice is powerful. This unit permits students to think of themselves as scientists even though society has historically not been permissive of that concept and it calls on them to be change-makers for the future.

Dr. Johnson's personal story really resonated with the students and allowed them to see her as someone who struggled to be where she is. She outwardly shared her experiences of becoming a PhD educated physicist in a world of men. Because of her story the unit really impacted students and provided them a reason to get outside their box because their teacher did. In the unit, students were expected to investigate careers that use Physics and use data that demonstrates students who are successful in Physics are qualified for many different careers. They investigated the value of a physics major in college and explored women who were ground breakers in Physics. They were immersed in scientists they had never heard of who were real people. Kind of like their teacher.

At Edison our students come from many different backgrounds and it is essential for them to see that the content of their education is relevant to their lives. They almost expect for it not to be and without that "buy in" to Physics from our students of color or our female students, their engagement will be limited. This unit, the STEM story unit and the diversity unit increased student engagement because the content was relevant to their life experience. The units also allowed Mr. Menz and Dr. Johnson to access background knowledge, a research based EL practice not normally important in the Physics classroom, and infuse that into the classroom instruction. Student stories were valued and the classroom became more than just the Physics. The units, although intended as a day-long or week long exposure experiences, became much more in our classroom. By separating the unit into two mini units at different times of the year allowed for the content to be a recurring theme in the class.

Physics is hard content, but sometimes the intimidation of the content is the barrier to learning hard things. The women in Physics unit and other practices in our classroom helped EL students, students of color and our white students see that Physics is for everyone, not just the select few. We have improvements to make and extensions to build upon, but without units like these in our challenging content areas we are only continuing the exclusivity of past practice. By valuing and supporting units like these in Physics we are leading from a place of inclusivity which will lead to the desired outcome of

Billy Menz is an EL Teacher at Edison High School with a B.A. in History from the University of Texas-Austin and a M.A. in English as a Second Language from Hamline University in St. Paul, MN. Mr. Menz has taught in K-12 education in Texas, Oregon, Pennsylvania and Minnesota for 19 years. This was Mr. Menz's first year at the high school level and at Edison High School.

Section on Teacher Preparation

Alma Robinson

Virginia Tech

This edition of the Teacher Preparation Section highlights the Physics Teacher Education Program Analysis (PTEPA) Rubric and the Next Generation Physics and Everyday Thinking (Next-Gen PET) curriculum.

The Physics Teacher Education Program Analysis (PTEPA) Rubric is a new instrument to help physics departments reflect on how to improve their physics teacher preparation programs by focusing on the characteristics and practices of thriving teacher preparation programs. Stephanie Chasteen and David May describe the value of the rubric in evaluating teacher preparation programs, how to use it, and when it might be particularly useful to implement it.

The Next Generation Physics and Everyday Thinking (Next Gen PET) is a guided-inquiry curriculum for physics or physical science designed for in-service or pre-service elementary education teachers (it is also appropriate for general education students). Edward Price, Fred Goldberg, Paul Miller, and Steve Robinson explain why this curriculum was developed; where instructors can go to find support and resources to adopt the curriculum; and how the Next Gen PET lessons align with the Next Generation Science Standards, are flexible to use in both lecture based and studio based university classrooms, and have shown to result in significant student learning gains.

If You Can't Measure It, You Can't Improve It: A Tool to Get Ideas to Improve Physics Teacher Education at Your Institution

Stephanie Chasteen, Chasteen Educational Consulting, David May, American Physical Society

Given the insufficient number of well-qualified future physics teachers in our country, you may be one of the many faculty members wondering how your program could do better. Some physics departments have yet to establish a pathway for their majors to achieve their license to teach. If this sounds like you, you are not alone! About 40% of physics departments have no physics teacher education program, and most departments do not graduate a single future physics teacher in a two-year period.[1] Even among the departments with teacher education programs, recruitment is a challenge; very few departments license more than two teachers in a year.

Regardless of your department's particular challenges, you may be aware of the wealth of reports and advice on how best to prepare future physics teachers (see phystec.org/publicity/). But how can you identify the best next steps?

The Physics Teacher Education Coalition (PhysTEC) was established in 2001 to improve and promote the education of future physics teachers through a wide variety of activities, including funding programs, undertaking research, and supporting the development of a physics teacher education (PTE) community (see phystec.org). The project has identified a need to help physics faculty analyze their local landscape vis-à-vis physics teacher education and choose strategies that will help address their local challenges. Based on systematic studies of what the strongest physics teacher education programs do, they have developed a set of 10 questions to ask yourself about your local program (see following page).

These questions (available as a downloadable handout at phystec.org/thriving) are good conversation starters for any program (including with administrators!). They are aligned with a specific measurement tool – a rubric – which was developed to help guide faculty and departments in their program strategy under the philosophy that "If you can't measure it, you can't improve it."[2] The rubric is thus intended to support self-assessment, feedback, reflection, and continuous improvement of local programs. It also serves as a catalog or "shopping list" of things that program leaders might consider focusing on for improvement. The Physics Teacher Education Program Analysis (PTEPA) Rubric was extensively developed and validated based on the features that thriving physics teacher education programs tend to have.[3]

How strong is physics teacher education at your institution?

10 questions for departments to consider

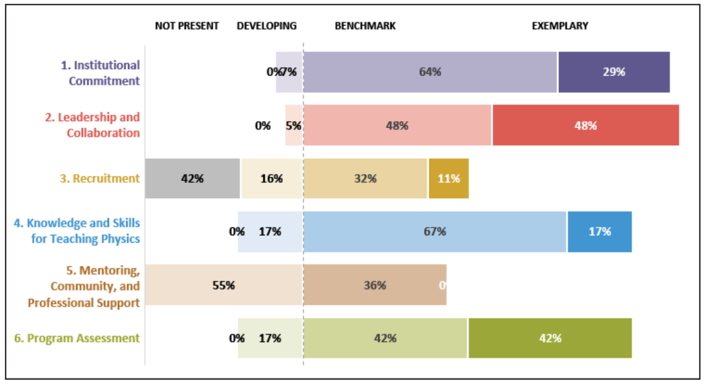
1. **Is there institutional support for your physics teacher education program and program team?**
2. **Do you have a strong program team?**
3. **How is your relationship with the School of Education?**
4. **Are you recruiting students into the program?**
5. **Are there streamlined and flexible pathways by which physics students may be certified to teach physics?**
6. **Does the program provide strong preparation in physics and physics pedagogy?**
7. **Does the program provide practical K-12 physics teaching experience?**
8. **Are future physics teachers mentored for career success?**
9. **Is there a community for physics teachers?**
10. **Do you assess and communicate program outcomes to generate support?**

Completing the rubric can be a good way to start a conversation with the school of education about certification options, or to gather a program team for self-reflection. Some faculty also plan to use it to advocate for resources, both internally, or externally, by identifying strengths, gaps, and improvements to the program. Possible opportunities for completing the rubric include:

- When applying for funding (e.g., Noyce, PhysTEC).
- When preparing to make a case to administrators for PTE program funding.
- When preparing annual reports on the PTE program.
- During PTE program planning or review.
- During department strategic planning or retreats.

A variety of supports are provided for interpreting PTEPA Rubric results, including an interactive Excel version of the rubric with automatic data visualizations and an ability to compare last year's results to the current year, an action planning template, and a User's Guide. At the top right is an example of sample program data, which shows the percent of items rated at each level within each category of the rubric - this (and other) visuals are available by sharing your data with us at phystec@aps.org.

Whether you are just starting out in physics teacher education or trying to improve an existing program, the rubric can serve as a useful tool to allow measurement and feedback that supports reflection and continuous improvement – leading to higher quality physics instruction for all. We are also eager to partner with researchers to further develop the rubric and use it in research



Percent of items rated at each level within each category of the PTEPA rubric

studies.

To learn more

PTEPA Rubric and associated materials: phystec.org/thriving

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David May is an education and diversity program manager at the American Physical Society, and the program manager for PhysTEC. He helps to develop, direct, evaluate, and manage the full portfolio of PhysTEC programs for improving the education of future physics teachers.

(Endnotes)

1. D. E. Meltzer, M. Plisch, and S. Vokos, *Transforming the Preparation of Physics Teachers: A Call to Action.* A Report by the Task Force on Teacher Education in Physics (T-TEP) (American Physical Society, College Park, MD, 2012).
2. Attributed to business expert Peter Drucker.
3. S. V. Chasteen, R. E. Scherr and M. Plisch, *A study of thriving physics teacher education programs: Development of the Physics Teacher Education Program Analysis (PTEPA) Rubric.* (American Physical Society, College Park, MD, 2018).

Teaching Physics or Physical Science to Prospective Elementary Teachers: A Flexible Curriculum and Faculty Community

Edward Price, California State University, San Marcos, Fred Goldberg, San Diego State University
Paul Miller, West Virginia University, Steve Robinson, Tennessee Technological University

By offering high-quality physics courses for prospective elementary teachers, departments can contribute to far-reaching improvements in science education. National calls by AAAS and the President's Council of Advisors on Science and Technology (among others), and efforts by APS and AAPT, such as the PhysTEC project, highlight the importance of this work. From a faculty perspective, working with future teachers is intellectually engaging and deeply gratifying, but it may feel daunting. Faculty may wonder about effective pedagogical approaches and appropriate content level. And departments may be unclear on how to support faculty to be effective in teaching these students. *The Next Generation Physical Science and Everyday Thinking* (Next Gen PET) materials, and the associated faculty online learning community (FOLC), are designed to address these issues.

Next Gen PET is a set of materials that can support a guided-inquiry, physics or physical science course for prospective elementary school teachers and general education students. Based on nearly two decades of development and evaluation, *Next Gen PET* is the successor to *Physics and Everyday Thinking and Physical Science and Everyday Thinking*. *Next Gen PET* is also appropriate for science methods courses or workshops for in-service teachers.

Relevance. According to NSTA, "nearly two-thirds of U.S. students live in states that have standards influenced by the Framework for K-12 Science Education and/or the Next Generation Science Standards."[1] NGSS describes three interrelated dimensions of learning: disciplinary core ideas, science and engineering practices, and crosscutting concepts.[2] The intent is that students should explore disciplinary core ideas "by engaging in practices... and should be helped to make connections to the crosscutting concepts." The NGSS also include engineering and technology standards, such as the inclusion of engineering practices.

While the Framework and NGSS are intended for K-12 science education, university courses that prepare future teachers should be consistent with the intended approach, integrating content, practices, and crosscutting concepts.[3] By aligning closely with NGSS, *Next Gen PET* helps students develop a deeper understanding of these ideas and how they emerge from engagement in the science and engineering practices. For example, *Next Gen PET* students learn to use energy diagrams for qualitative and quantitative analysis of energy changes and transfers during interactions by using the concept of efficiency to determine how energy flows through different branches of a system. Students use the diagrams to formulate and apply the idea of conservation of energy, thus engaging in the NGSS scientific practices of 'Developing and using models', 'Using Mathematics and Computational Thinking', and 'Arguing from Evidence', among others. This approach also aligns with the NGSS crosscutting concepts of 'Systems and System Models' and 'Energy and Matter: Flows, cycles, and conservation'.

Flexibility is designed into the *Next Gen PET* curriculum, with a Studio Class version for small lab and discussion classroom environments, and a Lecture Class version for lecture rooms and/or time-limited classes. The two versions include the same content in the same sequence, and share a common set of homework activities, allowing instructors to choose materials suitable for their course format. One main difference between the two versions is that, whereas in the studio version students perform their own experiments, in the lecture versions they watch videos of the experiments. Nevertheless, in both versions, students draw on evidence; discuss ideas; develop, test and modify models; and engage in practices of scientific argumentation.

Next Gen PET consists of five modules: Developing Models for Magnetism and Static Electricity; Interactions and Energy; Interactions and Forces; Waves, Sound and Light; and Matter and Interactions. Instructors can choose the content for their course from ten units (two per module) that have limited dependencies and are available separately from the publisher. Integrated *Engineering Design* activities require application of the module's physical science content. Optional *Planning and Conducting Investigations* activities provide opportunities for students to practice skills critical to the design and carrying out of their own investigations. Optional Teaching and Learning activities help students make explicit connections between their own learning; the learning and teaching of children in elementary school; and the core ideas, science and engineering practices, and crosscutting concepts of the NGSS.

Effectiveness

Students in *Next Gen PET* classes make significant gains in their conceptual understanding of the physical science content and in the science practice of explanation. During the last two years, nearly 50 faculty have administered pre-and post-course assessments, including conceptual multiple choice questions covering all content topics, and written tasks focused on energy and forces. Significant gains were evident in both science content and explanation.[4]

Support for instructors

Adopting a new curriculum can be daunting, but two supporting resources can help. A website for instructors provides access to pacing guidance, sample course sequences, copies of student materials, instructor presentation slides, test banks, equipment lists, ordering information, and more. The Next Gen PET FOLC is an associated online faculty learning community where faculty learn from each other, share resources and collaborate to improve their instruction, study student thinking, and conduct classroom-based research. The FOLC is ideal for faculty who are interested in *Next Gen PET* but are concerned about the time required to understand and adopt the materials. From a departmental perspective, the support and resources a faculty member receives in the FOLC can make it easier to launch or revamp a physics or physical science course for future elementary teachers. In the FOLC, faculty meet regularly by videoconference in small groups to discuss practical issues, facilitation strategies, and student learning. Online communication and file sharing tools (Slack, Google Docs) support collaboration between meetings. Interested faculty can learn more and apply to join the FOLC at the project website.

The science preparation of elementary teachers is an important piece of the broader science education landscape. The *Next Gen PET* curriculum and FOLC can help faculty and departments meet this need.

Acknowledgements.

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Paul Miller is a teaching associate professor of physics at West Virginia University. He piloted Next Gen PET in a hybrid lecture-laboratory format and is a faculty cluster leader on the NGP FOLC project.

Steve Robinson is a professor and chair of the Physics Department at Tennessee Technological University. He is one of the lead authors of the NGP curriculum and a co-PI on the NGP FOLC project.

1. National Science Teachers Association, "About the Next Generation Science Standards," <ngss.nsta.org/About.aspx>, accessed on 2018-08-30.

2. National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, Washington, DC, 2011).

3. National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K-8*, (National Academies Press, Washington, D.C., 2007).

4. P. V. Engelhardt, S. Robinson, E. Price, S. Smith, and F. Goldberg, Developing a conceptual assessment for a modular curriculum, *2018 PERC Proceedings* [Washington, DC, August 1-2, 2018], edited by A. Traxler, Y. Cao, and S. Wolf, doi:10.1119/perc.2018.pr. Engelhardt.

Browsing the Journals

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- The mysterious behavior of a short piece of PVC pipe spun on a table is investigated theoretically and experimentally on page 85 of the February 2019 issue of the *American Journal of Physics* (aapt.scitation.org/journal/ajp). In the same issue, the deformation of the lower portion of a bicycle tire is analyzed on page 102. Further, I added *Lost in Math: How Beauty Leads Physics Astray* to my summer reading list based on the Book Review on page 158. A helpful discussion of the concept of added mass for an object moving through a fluid is on page 165 of the March issue. A sealed bottle containing a little liquid nitrogen is placed at the bottom of a garbage can full of ping-pong balls; why does the can jump high in the air when the bottle explodes? See the article on page 255 of the April issue. In the same issue on page 264, Pearson discusses how "finely tuned" uranium-235 is for a fission chain reaction, with the usual humorous commentary about whether God had a choice in the matter. Finally, the editorial calling for high school physics teachers on page 328 of the May issue might be worth posting on a bulletin board in your department. I also enjoyed the treatment of a seesaw made by pivoting a candle through its midpoint and lighting the wick at both ends on page 370.
- Adam Neat has an accessible analysis of questions such as "Can we see objects having faster-than-light recessional velocities?" and "How far out into a spatially expanding universe can we see?" on page 80 of the February 2019 issue of *The Physics Teacher* (aapt.scitation.org/journal/pte). Scott Rubin numerically models a snowball rolling down a snowy slope (and getting bigger in radius as it does so) on page 150 of the March issue. The simultaneous equilibrium of forces and torques on a Roberval balance is worked out on page 166 of the same issue. In the April issue, Kelley Sullivan points out that a superball is considered more bouncy than a steel ball, even though the latter is actually more elastic, because the coefficient of restitution crucially depends upon the nature of the surfaces off which the balls are bounced.
- Article 025401 in the March 2019 issue of the *European Journal of Physics* reviews the quantum mechanical problem of an elastic ball bouncing vertically off a table and its connection with the equivalence principle. In the same issue, a concept inventory developed for the kinetic theory of fluids is discussed in article 025704. I do not recall having seen Editorials in this journal previously, but a pointed one worth a look is Bohren's "The curse of knowledge" in article 030201 of the May issue. Article 035008 of the same issue entertainingly considers the effects of gravity if the earth were flat. Article 023006 in the March 2019 issue of *Physics Education* proposes a simple demo of two water bottles connected by a string with one sliding on a tabletop and the other hanging over the edge. With the right amount of water in the two, the sliding bottle will just stop at the edge when the other bottle is released. A simple model of a vacuum bazooka which considers only two forces (the pressure difference on the two faces of the projectile and residual air drag) fits the observed speed versus time data well in article 033002 of the May issue. Article 035005 in the same issue shows that the rise of water in a capillary tube depends on the draft of the submerged portion of the tube, an effect which is normally neglected. Both journals can be accessed online starting at iopscience.iop.org/journalList.
- An interesting article on page 575 of the May 2019 issue of *Resonance* reviews the question of where the water on earth's surface came from, particularly in light of the the relative deuterium/hydrogen abundance ratio. It can be freely accessed at ias.ac.in/listing/issues/reso.
- The model of a particle in a quantum corral is discussed on page 82 of the January 2019 issue of the *Journal of Chemical Education.* A simple method to synthesize fluorescent carbon quantum dots is explained on page 540 of the March issue. Finally, an article on page 873 of the May issue discusses whether student responses to clicker questions should appear as polling progresses, or only after polling closes. The same issue also has an interesting analysis on page 926 of why the high-temperature heat capacities of gaseous nitrogen and fluorine are so different from each other. The journal archives are at pubs.acs.org/loi/jceda8.
- The inaugural issue of the journal *The Physics Educator* discusses the use of tonic water and phosphorescent paper to make laser light rays visible for demonstrations in article 1950006. The journal homepage is at worldscientific.com/worldscinet/tpe.
- Article 010120 in *Physical Review Physics Education Research* at journals.aps.org/prper/pdf/10.1103/PhysRevPhysEducRes.15.010120 considers how physics instruction about potential energy can help students understand electrostatic bonding energy between two oppositely charged ions in a subsequent chemistry course. Also see article 010103 at journals.aps.org/prper/pdf/10.1103/PhysRevPhysEducRes.15.010103 which shows that when measured values have more decimal places, students are less able to gauge the significance of the numerical differences between them; in other words, they think that if two numbers differ, it must reflect a physical difference, irrespective of the measurement uncertainty.

Web Watch

Carl Mungan, United States Naval Academy, <mungan@usna.edu>

- An elegant online edition of "The Elements of Euclid" can be browsed starting at c82.net/euclid/.
- I have heard good things about the free open-source vector graphics editor Inkscape. Check it out at inkscape.org/.
- A repository of free textbooks can be accessed at libretexts.org/.
- A quarter of a million items are said to be explorable from the Science Museum Group search page at collection.sciencemuseum.org.uk/.
- I recently ran across Springer's open access journal on STEM Education at stemeducationjournal.springeropen.com/.
- A Quebec-based Science Education Project to support high school teachers is described at mcgill.ca/sciedchantier7/.
- The Royal Society of Chemistry has an extensive education site at eic.rsc.org/.
- Browse and learn how to create instructional story maps (which are especially helpful in science education) at collections.storymaps.esri.com/how-to-stories/. Also see storymaps.arcgis.com/en/app-list/map-tour/.
- Read about Karen Uhlenbeck's winning of the Abel Prize in Mathematics at quantamagazine.org/karen-uhlenbeck-uniter-of-geometry-and-analysis-wins-abel-prize-20190319/.
- The American Academy of Arts & Sciences has a report titled "Perceptions of Science in America" at amacad.org/publication/perceptions-science-america and the follow-up report "Encountering Science in America" at amacad.org/publication/encountering-science. Also see the Pew Research Center report "What Americans Know About Science" starting at pewresearch.org/science/2019/03/28/what-americans-know-about-science/.
- Rhett Alain compares nuclear versus ion rocket engines at wired.com/2015/10/whatd-make-better-rocket-nuclear-ion-engines/.
- If you run a science article journaling seminar, you may wish to give the students a copy of the tips about reading scientific papers collected at sciencemag.org/careers/2016/03/how-seriously-read-scientific-paper.
- Videos and notes for flipped physics are being developed at flippingphysics.com/.
- Resources from the television program "Our Planet" are online at ourplanet.com/en/. Also browse National Geographic's animal species photo repository at nationalgeographic.org/projects/photo-ark/ as well as the educational aspects of deep-sea habitats at oceanexplorer.noaa.gov/okeanos/explorations/ex1903/background/edu/edu.html.
- Maths in a Minute explores various interesting mathematical puzzles and concepts in bite-sized pieces at plus.maths.org/content/maths-in-a-minute.
- A discussion of the 1919 eclipse expedition to confirm general relativity can be read at nytimes.com/2019/05/28/science/solar-eclipse-einstein-physics.html.
- It appears that an organic laser diode (as opposed to merely an OLED) has been finally realized, as described at phys.org/news/2019-05-laser-diodes-reality.html.

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Upcoming newsletter deadlines:

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