



UNDERGRADUATE PHYSICS PROGRAMS

# Equipping Physics Majors for the STEM Workforce

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**American Institute of Physics Career Pathways Project**

AIP Statistical Research Center

Society of Physics Students



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The Society of Physics Students (SPS) is a professional association explicitly designed for students. Membership, through collegiate chapters, is open to anyone. The only requirement for membership is that you be interested in physics. SPS exists to help students transform themselves into contributing members of the professional community.

[www.spsnational.org](http://www.spsnational.org)

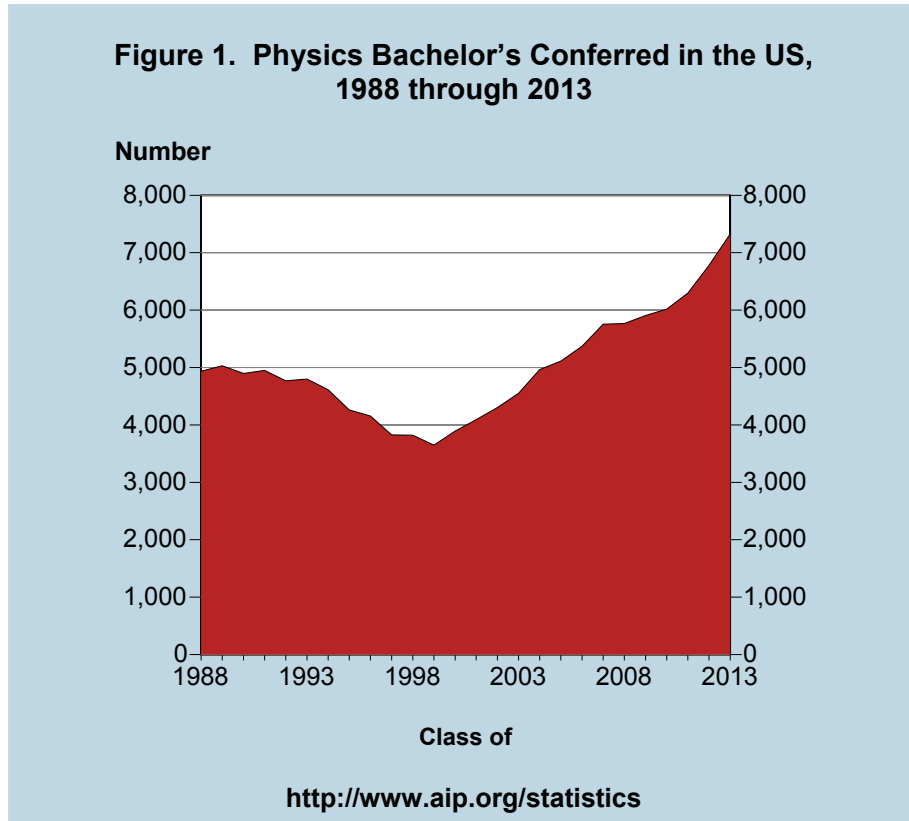
## Introduction

The Career Pathways Project (CPP) was designed to identify common features among physics departments with a strong record of preparing physics bachelor's for the science, technology, engineering, and mathematics (STEM) workforce and to disseminate that information to the physics community. By equipping physics departments and their students with tools for effective career preparation, CPP aims to increase the overall number and diversity of physics graduates, and of those joining the STEM workforce after the bachelor's degree. Departments that implement the curricular and extracurricular features identified by the project are likely to see improvement in both the recruitment and the retention of physics majors.

This report describes the project findings and, for each finding, suggests specific activities that faculty members can initiate or expand in their departments, concluding with a brief discussion about several ways to develop strategies for change. The Careers Pathways Project was funded by the National Science Foundation and carried out by staff members of the American Institute of Physics.

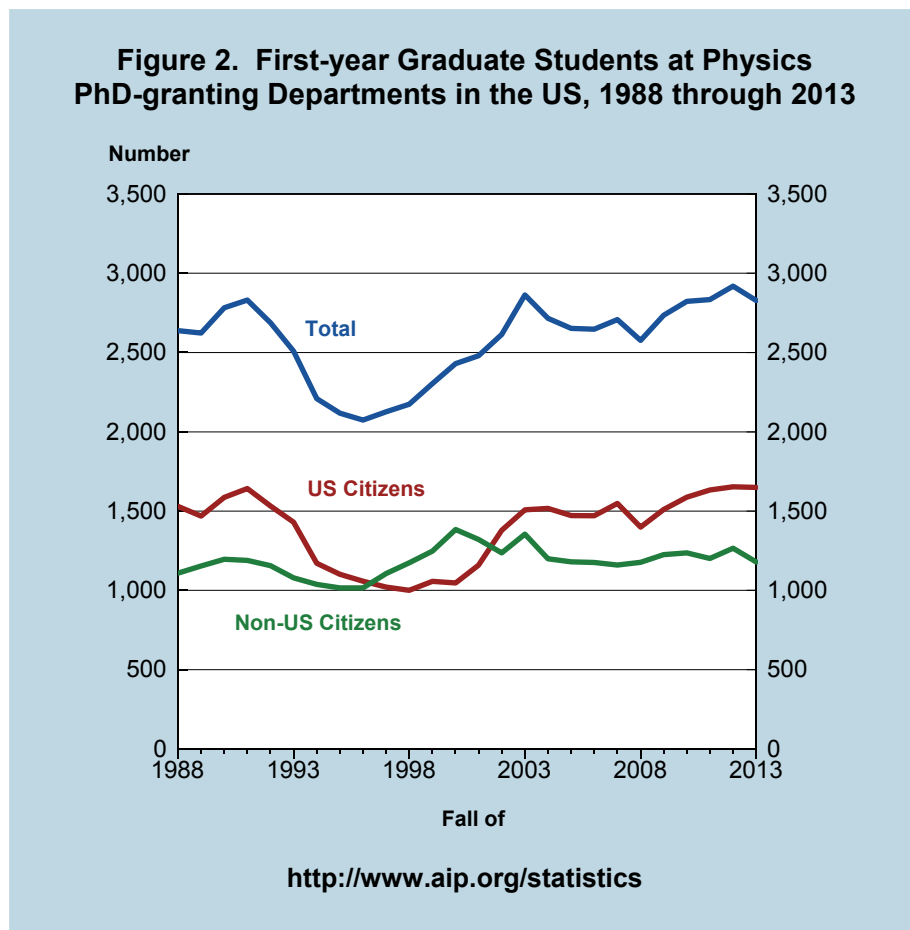
### Why Should Physics Faculty Members Care About this Report?

Physics bachelor's degree production in the United States has been steadily increasing for more than a decade (**Figure 1**). In fact, the number of physics bachelor's degrees awarded each year has doubled since 1999. The proportion of those graduates who have successfully entered

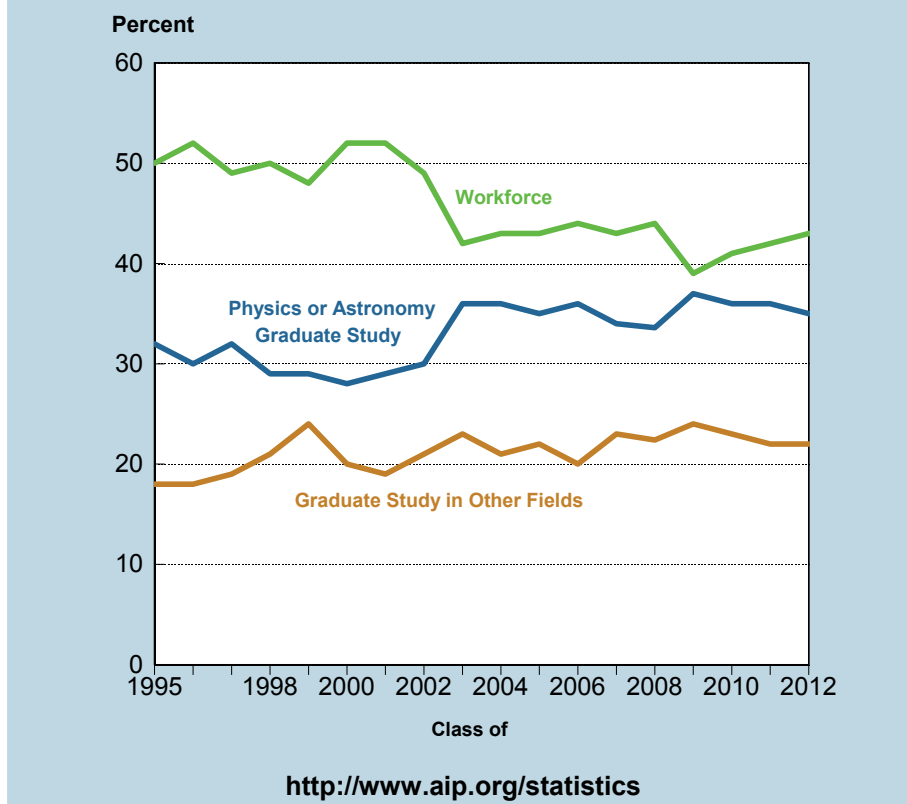


physics graduate school has remained high and domestic students have outnumbered foreign citizens among first-year graduate students in physics programs since 2002 (**Figure 2**). However, due to the wide range of interests, ambitions, personal goals, financial considerations, and other factors that influence the career trajectory of physics bachelor's degree recipients, as well as the limited number of openings for graduate students in physics PhD departments, since 2003 about 40% of each class of new physics bachelor's degree recipients has entered the workforce within one year of earning their degrees (**Figure 3**).

Although the number of physics bachelor's degrees in the United States has been hitting record highs, several physics departments around the country have had their bachelor's degree programs eliminated or considered for elimination due to low degree production compared to other majors. If the growth in physics bachelor's degrees is to continue, then physics faculty must address the enrollment and retention issues within their departments. By intentionally addressing the needs of the large portion of physics students who are interested in entering the STEM workforce after receiving a physics bachelor's degree, physics faculty members can serve a broader spectrum of their students, while also addressing several recruitment and retention issues along the way.



**Figure 3. Status of Physics Bachelor's in the US One Year After Degree, 1995 through 2012**



### **Brief Description of the Career Pathways Project**

The Career Pathways Project was a multifaceted study supported by a three-year grant from the National Science Foundation. The primary goal of the project was to identify and learn from a set of physics departments that were succeeding in graduating large numbers of physics bachelor's, many of whom entered the STEM workforce soon after graduating. (Appendix A provides a detailed description of how physics departments were selected for this study.) The design and methodology of this project was modeled after Project SPIN-UP: Strategic Programs for Innovations in Undergraduate Physics (2002).

Most of the data was collected during site visits to physics departments, and a questionnaire completed by department chairs provided important background information prior to the visits. Information collected from the site visits was analyzed with the goal of identifying features that seem to be related to departmental success in preparing physics students for the STEM workforce. The findings are being disseminated broadly through a variety of mechanisms, including talks and posters at physics professional society meetings and workshops for students and faculty. The findings also informed a set of resources designed for students that include a Careers Toolbox used in workshops for undergraduate physics students around the country and a related website, [www.spsnational.org/careerstoobox/](http://www.spsnational.org/careerstoobox/).

## Summary of Findings

The Career Pathways Project aims to help physics departments increase their physics bachelor's degree production by better preparing physics majors for the STEM workforce. Ten features were identified by CPP as common among departments that are effective in preparing students to enter the STEM workforce. Several of these common features are very similar to features identified by SPIN-UP in thriving physics departments. These are noted with an [S] in the list below. This overlap suggests that some of the features that help undergraduate physics departments thrive in terms of increasing bachelor's degree production also help them succeed when it comes to preparing students to enter the STEM workforce.

### *Curricular Features*

- Varied and high-quality lab courses
- Research opportunities for undergraduates [S]
- Curricular flexibility [S]
- Building communication skills as part of the undergraduate physics experience

### *Extracurricular Features*

- Faculty and staff commitment to physics majors' success at all levels, regardless of career goals
- Strong community of students within the physics department [S]
- Opportunities for physics majors to be involved in outreach activities
- Mentoring and advising physics majors in accordance with their interests and goals [S]
- Connections with alumni [S]
- Relationship with the career services office

## Detailed Description and Discussion of Each Finding

The next several pages are organized around the ten common features that make up the findings of the Career Pathways Project. The discussion of each finding has two parts. The first part speaks to the spectrum of activities that the authors include in that category and why those activities may affect success in preparing students to enter the STEM workforce. The second part lists specific examples of activities that faculty members may want to consider initiating or expanding in their departments, based on what was seen in the site visits.

The site visits illustrated that many of these features can be addressed with institutional changes (e.g., by implementing new degree programs) or with informal changes in the culture (e.g., by encouraging students to minor in fields that align with their other interests). In some of the departments visited the entire faculty was on board with the career preparation efforts, while others had only a few champions. While ideally all of the common features would be embraced by all faculty members in every physics department, the goal of this report is to present a wide array of opportunities for positive change. The variety of ways that common features have been implemented suggests that there are great opportunities for all departments, regardless of departmental culture, funding levels, and institutional politics. No department can implement every example listed, nor should they. The hope of the CPP team is that from among the examples, a few opportunities will resonate with each reader. For more on this, see "Considerations When Creating a Strategy for Change" on page 14.

## Curricular Features

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### ***Varied and high-quality lab courses***

Physics is a laboratory-based discipline. It is common to have physics courses for majors in the freshman and senior years that include lab components. However, several of the CPP departments provided, or even required, one or more lab courses during each of the four years. In addition, several offered a variety of different types of lab courses. Lab courses varied in terms of topic (e.g., electronics, optics), structure (e.g., students followed a detailed lab manual, students designed their own experiments), and use of equipment (e.g., students learned to use complex equipment, students used low-tech approaches), among other ways.

Through taking varied lab courses, students conduct experiments and collect data on a broad set of physics theories and gain practical experience with a variety of laboratory techniques, types of equipment, and software packages. These experiences are valued by employers because they teach students valuable skills like problem solving, troubleshooting, persistence, attention to detail, equipment operation, error analysis, data reduction, and teamwork.

Providing varied and high-quality lab courses has many benefits, but it also comes at a cost. Lab courses typically have a low ratio of students to faculty members, and thus they can be a considerable demand on faculty members' time. This was highlighted during a number of site visits. However, varied and high-quality lab courses offer strong benefits to the undergraduate students and they are powerful preparation for a diverse range of career pathways, including graduate school, employment in the STEM workforce, and teaching science at the high school level.

#### ► *What faculty members can do:*

- Assess the number and quality of lab-based courses available to majors in your department.
- Consider improving lab opportunities by offering additional or more varied labs, while also considering how to offset the increased faculty workload.
- Aim to provide a range of lab experiences that include opportunities to develop expertise with specialized software packages (e.g., LabVIEW) and software for statistical analysis, data display, modeling, and simulations.
- Working with a small number of students in a lab course gives a faculty member the opportunity to develop a detailed picture of students' abilities as researchers and their facility with specialized equipment. As a faculty member, draw on this knowledge when mentoring students about their career options and writing letters of recommendation for graduate school or providing references for employment.
- When coaching your students on preparing their resumes, ensure that they highlight the specific types of lab equipment and software with which they have worked that are relevant to the jobs they are seeking, and that they use verbs that clearly describe the level of experience they have with those technologies.

### ***Research opportunities for undergraduates***

Research opportunities for physics undergraduates can be part of the physics curriculum (e.g., senior capstone projects) or extracurricular (e.g., Research Experiences for Undergraduates), on or off campus, summer projects or projects that span multiple years. Some are paid and some are done for credit. Some departments require independent research for a physics degree, while others do not. The CPP departments featured different combinations of these opportunities, but faculty members at all of the institutions made known the opportunities and encouraged students to take advantage of them.

Undergraduate research experiences help students acquire essential knowledge, skills, and experiences in environments that are realistic, yet supportive. Research experiences provide majors with an in-depth understanding of the research process and help majors hone important cognitive skills like complex problem solving. They help physics students develop traits that are valued by employers across the economy, including determination, initiative, and teamwork, in addition to more specific skills valued by some employers. (For more information on these “21st-century skills,” see “Education for Life and Work” by the National Research Council of the National Academies.) They also provide students with excellent answers to common interview questions, such as “Tell me about an accomplishment you are most proud of,” and “Tell me how you handled a difficult situation.”

#### ► *What faculty members can do:*

- If a research experience is not part of your curriculum, consider implementing some kind of open-ended student-driven investigation as either a requirement or an option. Again, consider how to do so without overburdening faculty.
- Consider taking on undergraduate researchers and encourage your colleagues to do the same. Early engagement in research can be a strong recruitment and retention tool.
- Create a bulletin board or online database of relevant off-campus research experiences and internship opportunities. Make it a point to direct students to this resource. On many campuses, the career services office will help with this.
- If your school offers on-campus research opportunities, invite researchers to talk to physics students about their research and opportunities during departmental colloquia, Society of Physics Students (SPS) chapter meetings, or at a special event focused on research.
- Invite majors who are involved in or have completed research experiences to talk with majors, especially freshmen and sophomores, about what they learned and where they found the research opportunity.
- Encourage students interested in entering the workforce after their bachelor’s degree to explore doing research with local companies or laboratories.
- When coaching your students on preparing their resumes, ensure that they highlight their independent research experiences.



### *Curricular flexibility*

While physics majors may share a love of physics, they have unique interests and career ambitions. Many potential majors need or want to go to work immediately after earning their bachelor's degrees. It is certainly important to have a curricular option that prepares physics majors for physics graduate school, but many CPP departments have increased recruitment and retention by building flexibility into the curriculum to address the goals and needs of all physics majors—including those who want to enter the workforce or attend graduate school in something other than physics. Some departments offer traditional physics degrees as well as professional physics degrees that require fewer high-level theory courses and more hands-on, practical courses; others offer concentrations/minors/emphasis in related topics like medicine or astronomy; and others offer optional certificate training programs along the way to a degree. Many of these flexible programs rely on partnerships with other departments (e.g., computer science or biology), making them possible even in physics departments with only a few faculty members.

Having a flexible curriculum enables students to fulfill major requirements with courses that align with their career goals but may be outside of the traditional physics curriculum. For example, students interested in engineering who have the option of an engineering or applied physics major may be more likely to remain in the major instead of transferring to an engineering department. Students who are interested in computer science may be more likely to remain in the physics major if they can take computer programming and data analysis classes without adding an extra year to their degree pursuit. Students interested in medicine may be attracted by a medical physics or biophysics program. The traditional physics curriculum includes high-level theory courses that are necessary for physics graduate study, but may not be necessary for giving students a solid physics foundation that they can apply in a variety of other settings.

Another aspect of curriculum flexibility present in several CPP departments was the presence of a seminar class on careers using physics, often given to freshmen interested in majoring in physics, or a physics careers unit incorporated into introductory physics classes. Departments found these to be useful ways of keeping new students interested in physics while they were catching up on math requirements before being fully immersed in the major. Other departments incorporated career development activities (like resume writing) into junior or senior seminar classes.

#### ► *What faculty members can do:*

- Assess the common paths of your physics alumni and the interests of your students (and the students who quit the program) and consider whether it makes sense to expand your offerings. The possibilities are broad and could include both informal and formal changes, but here are some examples:
  - Actively encourage physics students to complete minors or second majors in line with their interests and ambitions, including in fields like economics, business, biology, journalism, education, and computer science.
  - Informally or formally incorporate concentrations or areas of specialization within the majors, e.g., physics education or biophysics.
  - Develop multiple physics degree programs to address students interested in attending graduate school, going right into the workforce (e.g., a professional

physics degree), or going into a related field (e.g., an engineering physics degree). These might include a common set of classes but diverge when it comes to upper-level requirements.

- Establish a dual-degree program, such as a physics–engineering 3-2 program where upon completion students earn a physics degree from one school and an engineering degree from a partner school.
- Provide physics majors with access to certificate or other training programs in specialized software packages that are valued by employers (e.g., LabVIEW), or in specialized equipment.
- Identify potential partner departments on your campus (e.g., medicine, business, education) and work with them to develop interdisciplinary courses of study that combine aspects of the disciplines.
- Consider ways to address physics career options directly through seminar classes or other departmental activities.

### ***Building communication skills***

CPP departments that integrated written or oral communication skills into the undergraduate physics experience did so in several ways. Some required that students write research papers or give presentations in every core class. Some required students to read and analyze articles, write summaries, and give presentations in journal clubs or seminar classes. Some provided opportunities for students to present their research to peers during SPS meetings, in a departmental colloquium, and at professional society meetings, or to participate in outreach or tutoring activities that required them to explain what they know to others.

The ability to communicate is essential in research careers, in teaching careers, and, in fact, in virtually all careers. Students who communicate well have an advantage when it comes to networking, writing cover letters and resumes, interviewing, and practically all of the steps along the job application process. Students who take advantage of opportunities to communicate their research to their peers and at professional society meetings may also benefit from increased exposure to potential colleagues and employers. The ability to describe problems and solutions clearly, work well with others, and build a case for support are highly valued in the STEM workforce.

#### ► *What faculty members can do:*

- Explicitly incorporate oral presentations and written assignments into the physics curriculum. In doing so, consider assigning a variety of exercises and activities (news articles, memos, technical papers, research papers, etc.) to develop public speaking and a wide range of writing skills. Incorporating a variety of types of communication assignments might also help students discover interests and abilities they have not previously explored, such as communicating science to the general public.
- Provide majors who engage in research experiences with a variety of opportunities to describe their work to people inside and outside of the physics department (in poster sessions, colloquium talks, meetings with donors or administrators, talks at professional society meetings, etc.).

- Encourage students to participate in outreach activities (e.g., working with middle school students or performing scientific demonstrations at the local mall) and tutoring to practice their teaching skills and reinforce their knowledge. Most activities intended to address Criterion II (i.e., Broader Impacts) of NSF grants can be used to provide physics majors with opportunities to develop public speaking and written communication skills.
- Encourage students to take elective classes in disciplines such as journalism, business, or theater that teach communication skills.
- Encourage or require students to work with the campus writing center on assignments. Consider inviting a representative from the writing center into a physics course or seminar to talk about its services or facilitate communication exercises.
- Consider forming a journal club or incorporate reading, writing, and discussing journal articles into SPS meetings or courses.

## **Extracurricular Features**

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### ***Faculty and staff commitment to physics majors' success at all levels***

During every CPP site visit, at least one physics faculty or staff member clearly articulated a commitment to helping every student interested in graduating with a physics degree to do so, regardless of the student's career goals. This is in contrast to many departments and faculty members that focus primarily on students with "graduate school potential" and measure the success of the department by the graduate schools their students attend.

The commitment to the success of every major in CPP departments was sometimes shared by all members of the department, and other times it reflected the passion of one or two individuals. In some places it influenced curriculum—for example, causing a department to reconsider math requirements that hindered otherwise-qualified students from majoring in physics, or leading to the introduction of multiple types of physics degrees. In other places the results were less formal, but were underscored by stories of struggling students who considered dropping out along the way but eventually succeeded and went on to very satisfying careers.

The stories we heard indicated that a focus on the success of every student can have a major impact on the recruitment and retention of majors. Students who feel valued and are encouraged to pursue their interests are more likely to stay in the major, and this helps create a departmental culture that is attractive to incoming students and students from other majors. In addition, even though physics faculty members may not always know how to advise students interested in careers outside of physics academia, those we met who were genuinely concerned about each student spent a lot of time learning about such opportunities and connecting students to them. However, this focus on the individual students comes with a cost. Time may be a faculty member's most precious commodity, and faculty members must balance their limited time between research activities, teaching requirements, and providing guidance and encouragement to majors.

#### ► *What faculty members can do:*

- Assess the values and culture of your department by considering the following: Is your physics department welcoming? Do you value undergraduates as important members of

the department's community? Do you support all students who are interested in physics or focus only on those interested in pursuing a graduate degree in physics? Is the department welcoming to potential majors who are unlikely to earn straight A's?

- Collect and disseminate opportunities for physics majors that go beyond traditional research experiences. This might include information on internships in industry, policy, or teaching, careers fairs (especially those targeted at STEM majors), interdisciplinary research experiences, and career and professional development workshops.
- Incorporate talks by physicists working outside of physics academia into your colloquium schedule, perhaps drawing on alumni or local industries.
- Talk about the variety of career options open to physics students in introductory physics classes and beyond. Consider including an introduction to physics careers in a freshman seminar or in SPS chapter meetings, perhaps using the Careers Toolbox.
- Deans and department chairs should ensure that they recognize and reward the time spent by faculty members mentoring, encouraging, and advising majors as a formal part of promotion and tenure decisions.
- Faculty members and staff should identify ways to encourage and support all physics majors, regardless of career goals and academic ability.

### ***Strong community of students within the physics department***

Physics departments vary significantly in terms of number of majors, type of school (i.e., small liberal arts or R1), number of faculty members, and teaching and research philosophies. However, a strong student community can exist in any type of department. In many of the departments visited for this project, a strong community was evidenced by a widely used student lounge that facilitated social gatherings and group work, and community bulletin boards that featured research opportunities and, in some departments, pictures of all of the majors. Many departments told site visit teams about traditions that were passed from one class to the next, SPS chapters or physics clubs that were welcoming to students from freshman to senior, and student-organized events ranging from outreach activities to study sessions to movie nights in the planetarium.

A strong student community has many benefits, including improved student performance, better retention of majors, and enhanced recruitment of potential majors. A strong student community can facilitate study groups, teamwork, and a support system. Majors can more easily become a vital source of information for each other about curricular and extracurricular issues. Of particular interest to this project, students at several schools reported that they heard about career opportunities, fellowships, and internships from recent graduates and upper-level students. In short, a strong student community is a benefit to everyone in a department.

#### ► *What faculty members can do:*

- Set aside a dedicated space for students to study and socialize. Ensure that students have access for late-night study sessions.
- Host departmental social events and invite students in introductory physics classes so they can interact with current majors.
- Encourage an active SPS chapter or physics club that can build morale. You might do this by providing departmental funding for events, attending meetings, offering to give a

talk at a meeting, bringing refreshments, offering to host study sessions, or in a variety of other ways.

- Work with students to create constructive rituals or traditions. For example, formally and publically recognize students when they declare a physics major, or have a spring awards banquet for all majors to recognize academic excellence.
- Foster strong student leadership. Encourage juniors and seniors to mentor or be peer counselors for freshman majors. Remember that the leadership of the physics club or SPS chapter turns over frequently and thus the new leaders need regular guidance and encouragement from faculty members.
- Set aside a portion of the department's budget for community-building activities such as monthly pizza lunches or a Pi Day party.
- Encourage your SPS chapter or physics club to participate in campus events like homecoming contests or parents weekend festivities.

### ***Opportunities for physics majors to be involved in outreach activities***

These opportunities can range from large-scale demo shows put on frequently by a department, to small, student-led classroom visits to local high schools. They can involve departmental open houses, haunted lab tours, booths in a local festival, or YouTube videos. Some CPP departments received funding from outside programs for large-scale outreach events, while others relied on departmental funding or fundraisers. The common thread was a focus on bringing physics to the public.

Regardless of the type of event, student participation in outreach activities has a tremendous variety of benefits. Many outreach activities strengthen the connection that students have with physics by providing them with an opportunity to put into practice and teach what they have learned in their classes and labs. Outreach activities can also be an effective tool for building a sense of community among students and can be a fun break from homework and exams. With regard to career preparation, participating in outreach activities can help to foster skills and traits that employers in all sectors value, e.g., leadership, public speaking, initiative, and teamwork.

#### ► *What faculty members can do:*

- Encourage students to identify ways to interact with the public regularly. Such activities can include demonstrations of physics phenomena at a local museum or shopping mall, open houses, telescope viewing nights, and much more.
- Help students connect with local teachers (maybe through your education department) and set up classroom visits to elementary, middle, or high schools. These visits could include demonstrations, teaching a lesson, tutoring, or mentoring.
- Provide financial support for student outreach efforts (usually needed for supplies and transportation).
- Provide guidance and expertise when students are planning activities, and recognize students who take on leadership roles in outreach with special awards.

### ***Mentoring and advising physics majors***

In most schools, faculty or staff advisors meet with majors to ensure that students are taking their academic requirements in the correct order and will successfully complete the physics bachelor's degree in an acceptable amount of time. Mentors tend to take a broader, long-range view and consider the career goals of the student. Formal or informal mentoring was present in most of the departments visited for this project. It did not fall exclusively on the shoulders of faculty members; in many places department staff members played a key role. In some departments one faculty or staff member served as the primary advisor and mentor for all of the students. In others, the responsibility was distributed among several people. In still others, the mentoring happened largely informally, for example, during hallway discussions and over pizza.

When a mentor and student discuss a student's interests and goals regularly, including those that go beyond physics course work, this can increase a student's feeling of value and the likelihood that he or she will stay in the physics major. Similarly, if the student receives constructive feedback about his or her skills and abilities, information on opportunities relevant to his or her interests, and overall encouragement from a mentor, this can better position the student to prepare for and find a job in line with his or her abilities and ambitions. Many mentors also connect students with their own personal contacts, help students write resumes, and refer students to valuable resources such as the career services office for additional help.

#### ► *What faculty members can do:*

- Assess your department's advising plan and whether it is conducive to mentoring.
- Spend time with your physics students to learn their aspirations, strengths, and shortcomings.
- Work with other faculty members to create a culture of informal mentoring by encouraging students to stop by faculty offices and holding joint social events for students, faculty, and staff. Even if you are not the SPS advisor, stop by SPS meetings to show your support. Stop by the student lounge occasionally to check in with students, and maybe even drop off a snack.
- Participate in training on mentoring, diversity, and sensitivity to ensure that your department is inclusive and welcoming to all students.
- Work with individual students to develop a roadmap of courses in physics and among electives that will help prepare them to achieve their goals.
- Become knowledgeable about the resources available to assist students in pursuing their goals, especially if they don't align with your own path. You can direct students to the career resources available on campus, as well as those online. Many scientific and professional societies have career-related resources, including the Society of Physics Students ([www.spsnational.org/cup](http://www.spsnational.org/cup)), the American Institute of Physics ([www.aip.org/career-resources](http://www.aip.org/career-resources)), and the American Physical Society ([www.aps.org/careers](http://www.aps.org/careers)). You can also direct them to the Careers Toolbox developed through this project ([www.spsnational.org/careerstoobox/](http://www.spsnational.org/careerstoobox/)).

### ***Connections with alumni***

Staying connected to its alumni has considerable value for a department, as well as for current majors. Understanding the careers that are commonly pursued by physics majors across the

country is important; however, knowing what becomes of physics majors from your university is essential. When you contact your physics alumni, you will learn about a broad range of possible career pathways and, more importantly, alumni will tell you which of those are common for the graduates from your physics department. This information can be very important in helping faculty members advise and recruit majors. Surveys indicate that physics alumni have very fond memories of their undergraduate days and that they are eager and willing to give back to the physics department. Alumni are often happy to provide guidance and leads to physics students looking for internships or even jobs in their field, to come back to campus and give a talk or meet with current students and faculty, to participate in mock interviews, and even to provide tours of their facilities to current students. Developing and maintaining connections with alumni represents a significant opportunity for many physics departments.

► *What faculty members can do:*

- Begin systematically tracking your alumni and stay in touch with them regularly, e.g., through an electronic newsletter about the physics department.
- Once you have a good understanding of where your graduates go and what they do, assess your curriculum and offerings in light of this knowledge.
- Consider a variety of ways to engage your alumni: connect them with students interested in their career path, and invite alumni to give colloquium or seminar talks, to serve on advisory boards, to departmental social events, and to meet with physics students.
- Establish a career day where alumni give talks, lead mock interviews, and review student resumes.
- Post a listing of alumni and their job titles on your physics department's website.
- Send an electronic newsletter to alumni, keeping them abreast of what is going on in your physics department.
- Treat your alumni that go into the workforce with respect and celebrate their accomplishments with your current students.

***Relationship with career services office***

Among the departments visited, we found few strong connections between the physics department and the career services office on campus, but this relationship was very impactful for the departments that had a strong relationship. For example, one department had a seminar for physics students, and several times throughout the semester a career services professional led the students through exercises and lessons on writing a resume, interviewing, and other practical job skills. Students learned to take advantage of the expertise of the career services office and of their physics faculty members, and in so doing, got the best of both worlds with regard to career preparation support.

The professionals in the careers office can assist students in areas beyond the expertise of most faculty members, e.g., self-assessment of skills valued by employers and mock interviews. However, the career services staff often has difficulty helping physics majors find jobs because very few jobs at the bachelor's level have the word physics in the title. To address this problem, the Career Pathways Project has published a list of common job titles held by physics bachelor's degree recipients working in engineering, computer science, scientific positions, and education. This is part of a larger "Fact Sheet for Career Professionals" produced by the project that is being

distributed to physics faculty members and career services offices around the country, and is available at [www.spsnational.org/cup/careerpathways/](http://www.spsnational.org/cup/careerpathways/).

► *What faculty members can do:*

- Invite staff members from the career services office to participate in a seminar or SPS meeting to talk about professional development skills such as resume writing.
- Download the “Fact Sheet for Career Professionals” from the SPS website and take a copy to the careers office and introduce yourself. Talk to the staff there about how you can work together to help physics students.
- Encourage your physics students to take advantage of the services offered by your career office: proofreading cover letters and resumes, holding mock interviews, and, in some places, an "interview closet" with clothes that students can borrow to look and feel professional during interviews.
- Help the career services staff connect with physics department alumni who can assist current majors in their career exploration activities and job searches.
- Work with the career services professionals to help physics majors identify the knowledge and skills that they should highlight in their resumes.

### **Considerations When Creating a Strategy for Change**

The SPIN-UP project report states on page 14 that “there is no evidence for a single magic bullet...that will make an undergraduate physics program thrive.” The Career Pathways Project found a similar result in this study on effective career preparation. There is no single feature that guarantees success and, in fact, there is no single set of features that guarantees success. Instead, faculty members should ask themselves what kind of physics program they want to develop and what kind of majors they want to attract and retain. If increasing recruitment and retention is a priority, then it may be worth considering some of the recommendations in this report.

The features described in this report are associated with effective preparation of physics bachelors for the STEM workforce. Several of the features were common among all of the departments that we visited, while other features appear to reflect the strengths of and opportunities available to specific physics departments. When deciding which new initiatives make sense at your institution, it is essential to consider your physics department’s unique characteristics and circumstances.

The profile of the freshmen who arrive on your campus is different from the profile of those who arrive on a campus 200 miles away. Your physics faculty members have a different set of interests, strengths, and shortcomings from the physics faculty members on a campus 200 miles away. The local economy that offers employment opportunities for your physics bachelor’s recipients is different from the economy surrounding a campus 200 miles away. The careers commonly pursued by your department’s alumni will look different from the national norms for all physics bachelor’s. As you decide on new activities to assist physics majors, be mindful of the strengths and shortcomings of your faculty, department staff, university, and local economy.



## Summary Comments

A significant fraction of physics majors and potential majors needs or wants to enter the workforce after completing their bachelor's degrees. Physics departments are in a unique position to help their students find great jobs and begin fulfilling careers. Doing so will not only help them, it will also help physics departments to recruit new majors and retain current majors. One day, grateful alumni may even be in the position to support your physics department and the next generation of physics majors.

Effectively preparing students to enter the STEM workforce looks different in different departments, but there are a number of common elements. We encourage all departments to develop a strategy for change that builds on the interests and goals of your students and incorporates the strengths of your physics faculty members, your university, and your regional economy.

The features described in this report are associated with a solid preparation for the STEM workforce. However, there is significant overlap between our findings and the common features of thriving physics departments identified by Project SPIN-UP. Thus we conclude that many of the activities described in this report will help all physics bachelor's succeed across the full spectrum of career paths that they choose to pursue and will help all physics departments thrive.

### References

SPIN-UP Project Report, 2002

<http://www.aapt.org/Programs/projects/spinup/upload/SPIN-UP-Final-Report.pdf>

SRC report: Roster of Physics Departments with Enrollment and Degree Data

<http://www.aip.org/statistics/reports/roster-physics-2013>

SRC report: Physics Bachelor's One Year After Degree

<http://www.aip.org/sites/default/files/statistics/employment/bach1yrafterdeg-p-12.pdf>

SRC report: First Year Physics Graduate Students

<http://www.aip.org/sites/default/files/statistics/graduate/1styeargrad-p-10.pdf>

## **Appendix A: Selection Criteria and the Physics Departments That Were Visited**

Over the course of three academic years, the Career Pathways Project conducted eight site visits of physics departments. The departments were chosen because of their strong record, both of graduating students with bachelor's degrees in physics and of these students immediately entering the STEM workforce. The departments were selected to represent five different categories of physics departments: public and private bachelor's-granting physics departments, departments that award a master's as their highest physics degree, and small and large PhD-granting physics departments.

Data collected by the Statistical Research Center of the American Institute of Physics in several annual surveys were used to identify physics departments that:

- had a strong record of granting physics bachelor's degrees compared to other physics departments within their type; and
- were among the national leaders in terms of the percent of their recent physics bachelor's recipients who entered the STEM workforce within one year of earning their degrees.

The two criteria above were used to identify the top ten physics departments in each of the five categories. To further refine this list, the principal investigators reviewed the websites of all the physics departments that met the criteria to select those that included the best information about the careers commonly pursued by physics bachelor's degree recipients. The final selections were made with an eye toward providing some geographic balance. Compared to departments in similar institutions, the physics departments that passed the review of their websites were rated as among the five strongest in terms of production of bachelor's degrees and the preparation of their recipients for the STEM workforce.

Each site visit was accomplished over a two-day period by a team of three people. One of the CPP investigators served as the lead for each team and took responsibility for compiling a comprehensive report about the visit.

The CPP investigators take this opportunity to thank the site visit volunteers for their participation, as well as the department chairs and staff at each of the following institutions for organizing the visits and for preparing extensive background material for the site visit teams.

## Site Visit Teams

### ***Gettysburg College (PA)***

Apr 26–27, 2011

Thomas Olsen, American Institute of Physics (lead)

Kendra Redmond, American Institute of Physics

Roman Czujko, American Institute of Physics

### ***University of Washington***

May 15–16, 2011

Thomas Olsen, American Institute of Physics (lead)

Mary Fehrs, Pacific University

Henri Jansen, Oregon State University

### ***University of California at Davis***

May 19–20, 2011

Thomas Olsen, American Institute of Physics (lead)

Mary Fehrs, Pacific University

James Hollenhorst, Agilent Technologies

### ***University of Wisconsin at Eau Claire***

Feb 23–24, 2012

Kendra Redmond, American Institute of Physics (lead)

Brian Beecken, Bethel University

Gary White, Society of Physics Students

### ***University of Wisconsin at La Crosse***

Mar 4–6, 2012

Kendra Redmond, American Institute of Physics (lead)

Brian Beecken, Bethel University

James Eckert, Harvey Mudd College

### ***Carthage College (WI)***

Mar 7–8, 2012

Kendra Redmond, American Institute of Physics (lead)

Robert Benjamin, University of Wisconsin-Whitewater

Ruth Howes, Ball State University

### ***Miami University of Ohio***

Sep 16–17, 2012

Roman Czujko, American Institute of Physics (lead)

Diane Jacobs, Eastern Michigan University

Jack Hehn, American Institute of Physics

### ***College of Charleston (SC)***

Feb 7–8, 2013

Roman Czujko, American Institute of Physics (lead)

Diane Jacobs, Eastern Michigan University

Jack Hehn, American Institute of Physics

# Finding the Report Online

Equipping Physics Majors for the STEM Workforce is available on two AIP websites:

<http://www.aip.org/statistics/undergraduate>

<http://www.spsnational.org/cup/careerpathways>

If you have questions or comments, please contact the senior authors:

Roman Czujko at 301-209-3080 or [rczujko@aip.org](mailto:rczujko@aip.org)

Kendra Redmond at 301-209-3047 or [kredmond@aip.org](mailto:kredmond@aip.org)

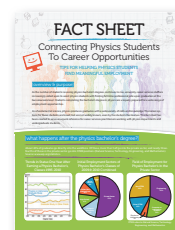
## Careers Toolbox for Physics Students

The Careers Toolbox for Undergraduate Physics Students is a set of tools and exercises designed to help undergraduate physics students prepare to enter the science, technology, engineering, and mathematics workforce. Tools range from exploring the common job titles of physics bachelor's to preparing for interviews, and are all geared specifically for physics students. <http://www.spsnational.org/careerstoobox/>



## Fact Sheet for Career Professionals

This guide, created by the Career Pathways Project, is a resource designed to enhance the work being done by career services professionals with physics undergraduates and faculty. The Fact Sheet includes information on the common career paths of physics bachelor's recipients, resume and career advising tips, suggested databases for finding physics-related internships and jobs, and more. <http://www.spsnational.org/cup/careerpathways/>



## e-Updates

You can sign up to receive e-mail alerts from the AIP Statistical Research Center which notify you when we post a new report. You can indicate your area(s) of interest; we will send you an e-Update only when we post a new report that includes data of interest to you. If you sign up for every possible notification, you should receive no more than twenty messages in a year. To sign up, visit [http://www.aip.org/statistics/e\\_updates](http://www.aip.org/statistics/e_updates).

