A Study of Thriving Physics Teacher Education Programs

Development of the Physics Teacher Education Program Analysis (PTEPA) Rubric

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A Publication of the PhysTEC Project
JULY 2018

July 2018

A Study of Thriving Physics Teacher Education Programs: Development of the Physics Teacher Education Program Analysis (PTEPA) Rubric.

Published by

American Physical Society
One Physics Ellipse, College Park, MD 20740-3844

A project of the Physics Teacher Education Coalition (PhysTEC)
The PhysTEC project is led by the American Physical Society and the American Association of Physics Teachers. More information at www.phystec.org.

Additional documents related to this report, including the most recent version of the rubric, are available at www.phystec.org/thriving.

Funding

This report was supported in part by the National Science Foundation under grant numbers PHY-0808790 and PHY-1707990 and the APS 21st Century Campaign. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Recommended citation

Stephanie V. Chasteen, Rachel E. Scherr, and Monica 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). Accessed at http://phystec.org/thriving.

Design and layout by Nancy Bennett-Karasik, Leanne Poteet, and Meghan White.

Cover image by Craig Terry.

ISBN: 978-0-9982529-0-2

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Acknowledgments

The authors gratefully acknowledge the contributions of the following individuals:

We thank the gracious hosts and teams at the programs visited for the study (described in Appendix A3) for hosting visits, participating in interviews, and reviewing the PTEPA Rubric results and reports: **Michael Marder** (University of Texas at Austin), **Valerie Otero** (University of Colorado Boulder), **Duane Merrell** (Brigham Young University), **Chance Hoellwarth** (California Polytechnic University, San Luis Obispo), **Brian Thoms** (Georgia State University), **Karen Magee-Sauer** (Rowan University), **Eugenia Etkina** (Rutgers University), and **Keith Sheppard** (Stony Brook University).

Additionally, we acknowledge the contributions of the following: **Gay Stewart** (West Virginia University), **Stamatis Vokos** (California Polytechnic University, San Luis Obispo), and **Wendy Adams** (Colorado School of Mines) provided expert review and feedback on the PTEPA Rubric from a physics teacher education perspective. **Judy Oakden** (Pragmatica) provided review of the instrument from an evaluative rubric perspective. **Claudia Fracchiolla** (National University of Ireland Galway) created the interactive Excel version of the PTEPA Rubric. **Justyna P. Zwolak** (Joint Center for Quantum Information and Computer Science) provided data analysis and visualization, and **Jessica Alzen** (University of Colorado Boulder) provided feedback on data interpretation and conducted some analysis. **Anthony Ribera** (Rose-Hulman Institute of Technology) provided review of academic accreditation processes. **Melissa Holt** (Sunny Side Support) provided copyediting services. **Renee-Michelle Goertzen** and **David May** of the American Physical Society provided invaluable managerial support for the project.

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EXECUTIVE SUMMARY

MOTIVATION

Given the severe shortage of high school physics teachers across the United States, there is an urgent need for institutions of higher education to increase the number of highly qualified candidates graduating from physics teacher education programs. To help meet this need, the Physics Teacher Education Coalition (PhysTEC) project conducted a study of "thriving" physics teacher education programs (defined as programs that frequently graduate five or more physics teachers per year). The goal of the study was to identify common practices and structures of these highly successful programs so that these approaches may be emulated by other physics teacher education programs.

A new instrument, the Physics Teacher Education Program Analysis (PTEPA) Rubric, was developed to characterize the practices and structures observed at thriving programs. The PTEPA Rubric also provides a specific, objective, and reliable guide for physics teacher educators seeking to improve their programs. The rubric is designed to characterize physics teacher education programs and enable comparisons with thriving programs, thus providing guidance for self-improvement, enabling measurement of program growth, and allowing aggregation of data across different programs.

STUDY METHODS

Through extensive engagement with theory, analysis of existing instruments, review of relevant studies, and direct observations of thriving programs, independent researchers and PhysTEC staff collaborated on the development of the PTEPA Rubric, creating a tool to characterize the practices and structures associated with successful programs.

The independent researchers conducted in-depth visits to eight thriving physics teacher education programs: the University of Texas at Austin; the University of Colorado Boulder; Brigham Young University; California Polytechnic University, San Luis Obispo; Georgia State University; Rowan University; Rutgers University; and Stony Brook University. The programs were all located at large universities but otherwise were selected to represent the full diversity of thriving programs (half had received PhysTEC funding and half had not, some were undergraduate programs and some were post-baccalaureate, a couple were UTeach[1] programs, and so on). Program visits were conducted either in person or virtually, and each visit involved interviews with a wide variety of stakeholders, including program leaders, administrators, teachers, staff, and students.

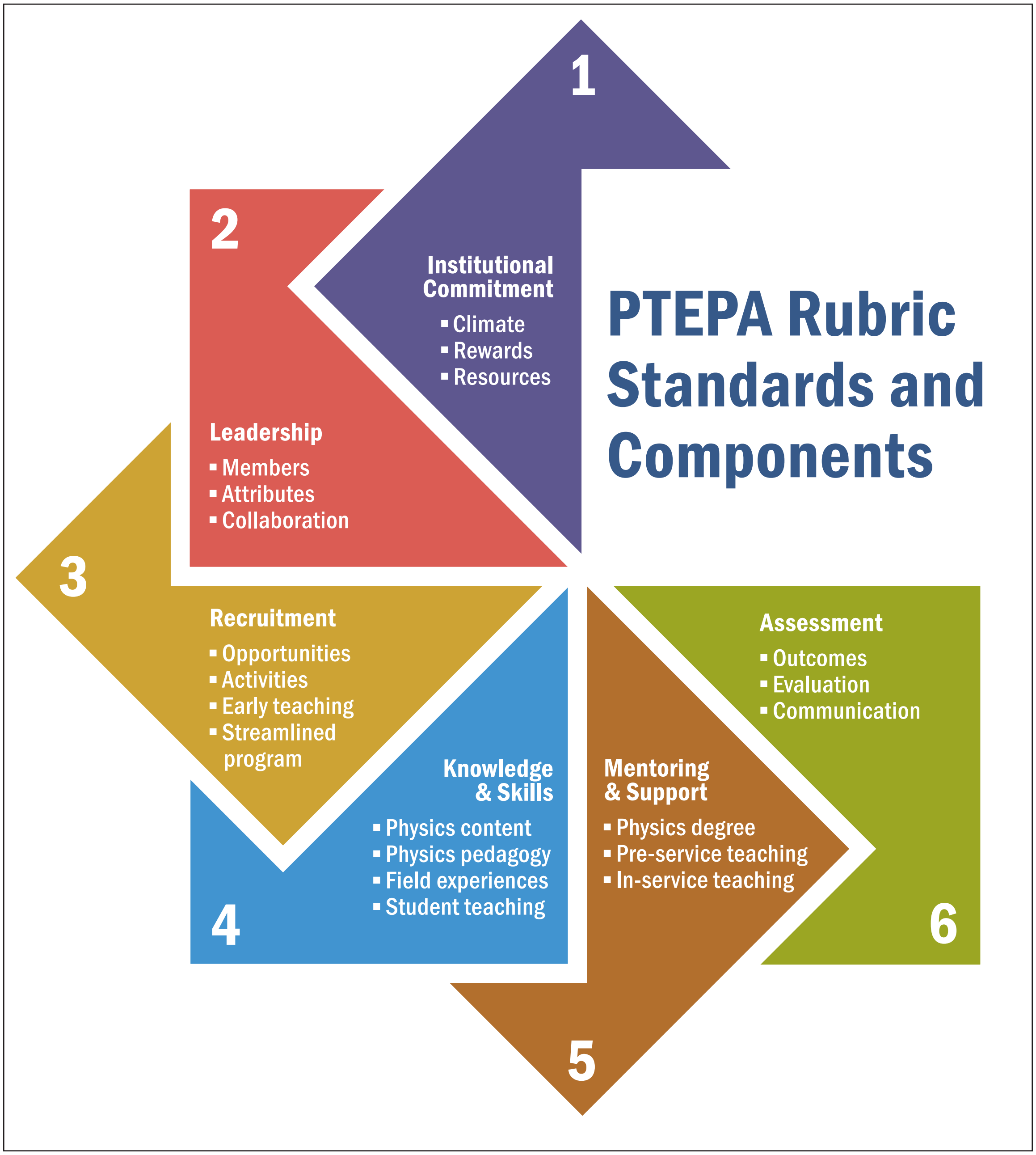
Analysis of the data from thriving programs contributed strongly to the development of the rubric, provided initial validation, and supported research findings. Review by nationally recognized experts in physics teacher education as well as extensive alignment with literature and accreditation processes established substantive validity, content validity, and face validity. During the development and validation process, the PTEPA Rubric was iteratively improved through over 20 versions to better reflect the practices and structures of diverse thriving physics teacher education programs.

STRUCTURE OF THE PTEPA RUBRIC

The PTEPA Rubric is organized into six standards: (1) **Institutional Commitment**, (2) **Leadership and Collaboration**, (3) **Recruitment**, (4) **Knowledge and Skills for Teaching Physics**, (5) **Mentoring and Professional Support**, and (6) **Program Assessment.** Each standard has three or four components within it that address specific subtopics, and each component has two to eight individual items. Each item in the rubric may be rated for a particular program as Not Present (NP), Developing, Benchmark, or Exemplary. Programs meeting a "Benchmark" level perform at a recommended level on the item.

The PTEPA Rubric is intended to be used primarily as a self-study instrument. It is provided as a fillable PDF or an interactive Excel spreadsheet with built-in visual representations of results. It is best completed by a program team, in consultation with key stakeholders, to get the most accurate program ratings and best interpretation of results. The rubric results may best support continuous improvement when communicated to stakeholders and used to drive a program action plan. You may access the PTEPA Rubric and its associated materials at http://phystec.org/thriving.

Figure 1: The PTEPA Rubric standards and components.



FINDINGS ABOUT THRIVING PROGRAMS

Data on the eight thriving programs studied have resulted in several preliminary findings, which offer some guidance for physics teacher education programs (though causality has not yet been determined).

1. The thriving programs studied are strong in multiple standards of the PTEPA Rubric, indicating that a broad range of activities occurs in thriving programs.
2. Programs were most consistently strong in **Standard 1: Institutional Commitment** and **Standard 2: Leadership and Collaboration**, suggesting that these standards may be particularly important.
3. Different programs are strong in different standards, and programs show variable performance in particular components within the standards; thus, different thriving programs embody different patterns of teacher education activity, likely depending on local context.
4. Certain components were consistently highly rated among thriving programs.
5. Certain items were consistently highly rated across the studied programs. These items were denoted within the instrument as “Prevalent.” Such consistently highly rated components and Prevalent items may be particularly important to the success of thriving programs and may offer focal points for program improvement, although further research is needed to confirm a causal relationship.
6. Even thriving programs do not achieve Exemplary ratings in all areas. Thus, not all PTEPA Rubric elements are essential for success in all programs. Thriving programs were also observed to encounter many challenges on the way to achieving success.

RECOMMENDATIONS

Based on the results of this report, we recommend the following:

1. **Program leaders** should complete the PTEPA Rubric, consider aligning their practices with thriving programs, and engage in continuous improvement based on results. This may help to increase the number of qualified physics teachers graduating from the program.
2. **Education researchers and evaluators** should expand the validity of the PTEPA Rubric and investigate hypotheses about physics teacher education programs, such as whether increasing ratings on the PTEPA Rubric is associated with increasing teacher graduation rates. This activity has the potential to further refine the rubric for use and contribute to the knowledge base on physics teacher preparation.
3. **PhysTEC staff** should continue testing on and improvements to the usability of the PTEPA Rubric and create supportive policies and incentives for its use.

ENDNOTES

1 UTeach is a STEM teacher preparation program originating at the University of Texas at Austin with replication programs around the country. See https://institute.uteach.utexas.edu.

CHAPTER 1

Why Measure What Thriving Programs Do?

This study identifies common elements of thriving physics teacher education programs in order to support other programs in emulating them. This work resulted in development of a rubric to characterize physics teacher education programs.

MOTIVATION FOR THE STUDY OF THRIVING PROGRAMS

The Physics Teacher Education Coalition (PhysTEC) project was launched in 2001 by professional societies concerned about the severe shortage of qualified high school physics teachers. Since that time, the project has directly supported dozens of institutions to build model programs with the goal of increasing the number of graduates highly qualified[1] to teach physics. Based on experience with these model programs, PhysTEC developed a set of Key Components[2] that include activities and program structures judged to be important for a successful physics teacher preparation program.

The PhysTEC Key Components have been useful for focusing attention on critical features that are typically not present in many programs; however, it has not always been clear what a program should do to achieve the Key Components or how a program should assess their implementation. Further, some programs have been more successful than others in increasing the number of physics teachers they graduate each year, and it would be useful to better understand the factors that underlie the success of the most productive programs.

PhysTEC engaged independent evaluators and researchers to conduct a study of "thriving" physics teacher education programs to characterize and analyze their practices. "Thriving programs" are defined as physics teacher education programs at large universities that frequently graduate five or more highly qualified physics teachers in a year.

A total of eight institutions participated in the study: the University of Texas at Austin; the University of Colorado Boulder; Brigham Young University; California Polytechnic University, San Luis Obispo; Georgia State University; Rowan University; Rutgers University; and Stony Brook University. Four institutions were PhysTEC sites, and four had programs established through other initiatives.

The diversity of programs was intended to elicit program activities and structures that might not be included in the PhysTEC Key Components since all PhysTEC sites were required to address the Key Components as a condition of receiving funding. The results of the analysis are detailed in Chapter 3: "What Has Been Learned About Thriving Programs?"

A future teacher leads an interactive discussion about trigonometric functions. TWAY PHOTOGRAPHY

MOTIVATION FOR THE PTEPA RUBRIC

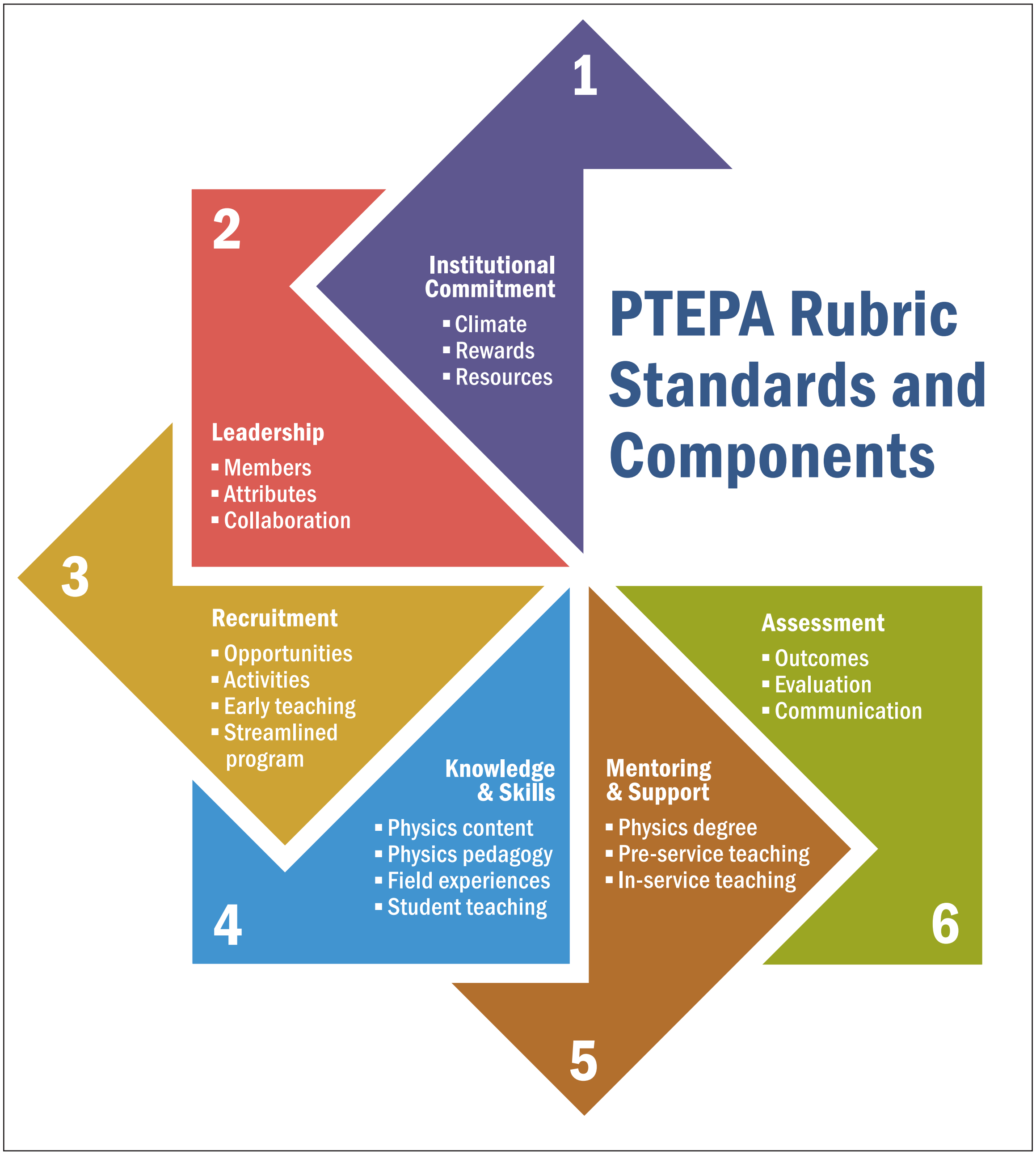
The Physics Teacher Education Program Analysis (PTEPA) Rubric was developed as a tool to characterize the practices and features of thriving physics teacher education programs. The rubric provides a taxonomy of the types of activities and structures implemented in successful physics teacher education programs and describes different levels of achievement for programs to measure the relative strength of each activity. The rubric is intended to offer programs a catalog or "roadmap" of best practices, to guide programs in self-reflection toward improvement, to provide feedback on their progress, and to provide a means to characterize program growth. It is also a tool to enable future research studies, allowing comparison of different programs, aggregation of information on activities across programs, and investigation of how common features of programs and practices correlate with physics teacher graduation rates. PhysTEC has made a substantial investment in the development of this instrument, foreseeing utility both for individual physics teacher education programs and for the national project.

OVERVIEW OF THE PTEPA RUBRIC

The PTEPA Rubric was initially informed by existing statements of common features of successful physics (or science) teacher education programs, which included the PhysTEC Key Components and several other instruments and reports. However, the most significant effort in developing the PTEPA Rubric went toward shaping the rubric to reflect observations at the eight diverse thriving programs featured in the study. Development of the structure of the rubric was a significant effort, with items, components, and standards iterated over many versions to find an organization that was meaningful. The development and validation of the PTEPA Rubric are summarized in Chapter 2: "How Were Elements of Thriving Programs Determined?"

The PTEPA Rubric is organized into six standards: (1) **Institutional Commitment**, (2) **Leadership and Collaboration**, (3) **Recruitment**, (4) **Knowledge and Skills for Teaching Physics**, (5) **Mentoring and Professional Support**, and (6) **Program Assessment**. Each standard has three or four components within it that address specific subtopics, as shown in Figure 1. Each component has two to eight individual items that describe

Figure 1: The PTEPA Rubric standards and components.



specific program activities or structures. Some of the individual items are identified as "Prevalent," meaning that many thriving programs have been observed to demonstrate a strength in that item; other items are less consistent across thriving programs but were still observed at some programs. Examples of how different programs address the PTEPA Rubric standards are presented in Chapter 4: "What Are Some of the Strongest Elements Observed at Thriving Programs?"

The PTEPA Rubric is provided in Appendix A1; additionally, the PTEPA Rubric Snapshot gives a brief overview of the instrument. See http://phystec.org/thriving for the most recent copies of both documents.

For each of the PTEPA Rubric items, researchers identified concrete hallmarks of the range of levels at which a program may exemplify that feature. Each item in the rubric may be rated for a particular program as Not Present (NP), Developing, Benchmark, or Exemplary, as defined in the table.

Level	Description
Not Present (NP)	Item is not present in the program.
Developing	The program performs better than a typical U.S. institution of higher education on that item.
Benchmark	The program performs at a recommended level on that item.
Exemplary	The program is among the best-performing on that item.

VALIDITY AND USE OF THE PTEPA RUBRIC

The PTEPA Rubric was developed to measure features commonly observed in thriving physics teacher education programs. As discussed extensively in Chapter 2, the PTEPA Rubric has undergone multiple forms of validation for this specific purpose.

Thus far, the PTEPA Rubric has only been systematically applied to *thriving* physics teacher education programs. In general, PTEPA Rubric results for a given program indicate the extent to which that program has the same features as the studied thriving physics teacher education programs. This may indicate the extent to which a program can expect to successfully recruit, educate, and professionally support large numbers of physics teachers, though this interpretation has not yet been substantiated by research. Best practices are context dependent; physics teacher education programs need to adapt their activities and structures to their individual goals, environments, resources, and constraints. The PTEPA Rubric is not intended as a checklist of universal standards that all physics teacher education programs must follow. Recommendations for leveraging your use of the PTEPA Rubric for program improvement are included in Chapter 6: "How Can You Use the PTEPA Rubric, and What Do Your Results Mean?"

The PTEPA Rubric was designed to characterize features of *physics* teacher education programs. It focuses on items that require engagement by physics disciplinary experts, departments, and faculty, who are the primary audience for this report. The PTEPA Rubric does not include items that lie exclusively in the domain of schools of education. This choice was made because while there are many studies and reports about STEM teacher preparation, relatively few emphasize the critical role of disciplinary faculty in developing successful programs. Teacher education programs without an interest in physics-specific teacher preparation may not find the PTEPA Rubric to be well suited to their activities and structures, although items may well translate to other STEM disciplines with severe teacher shortages. Similarly, integrated *science* teacher education programs may find that many PTEPA Rubric items are not relevant to their program goals.

SUMMARY

A study of thriving physics teacher education programs enabled identification of common practices at such programs, which will help guide other programs in emulating their success. The PTEPA Rubric is a tool for characterizing physics teacher education programs based on these common practices. As a guide for physics teacher education program self-reflection and improvement, it is intended to be a more specific, objective, and reliable evolution of the PhysTEC Key Components with the added benefit of providing assessment indicators.

ENDNOTES

1 PhysTEC defines highly qualified teachers as those with a major or minor in physics (or equivalent coursework) who have completed a teacher education program leading to certification.

2 See PhysTEC Key Components at https://www.phystec.org/keycomponents/.

CHAPTER 2

How Were Elements of Thriving Programs Determined?

The elements of thriving programs were determined with reference to theory, literature, and observations of thriving programs. The PTEPA Rubric provides a valid tool for characterizing programs in terms of these elements.

INTRODUCTION

The purpose of the thriving programs study was to identify the elements of thriving physics teacher education (PTE) programs (defined as consistently producing five or more physics teachers per year) and thereby offer support for other programs to emulate such successful programs. Through extensive engagement with theory, existing instruments, and observations of thriving programs, researchers and PhysTEC have collaborated to develop the Physics Teacher Education Program Analysis (PTEPA) Rubric to measure the practices and structures associated with thriving programs.

In-depth visits to thriving programs have been among the most formative influences on the PTEPA Rubric. Analysis of the data from these visits has contributed to iterative development of the rubric, provided initial validation, supported research findings, documented the strongest elements in these programs, identified challenges faced by these programs, and supported development of written case studies describing these program approaches. Further validation of the rubric has included review by nationally recognized experts in physics teacher education as well as extensive alignment with literature and accreditation processes, thereby establishing substantive, content, and face validity. During this year-long validation process, the PTEPA Rubric was iteratively modified through over 20 versions to better reflect the practices and priorities of diverse thriving physics teacher education programs.

DEVELOPMENT OF THE PTEPA RUBRIC

Theoretical Premises

Creating a rubric is an opportunity to surface implicit values and desired outcomes in a project, bringing attention to key aspects and creating shared and explicit understanding about what matters (King, McKegg, Oakden, and Wehipeihana, 2013; Allen and Tanner, 2006). The PTEPA Rubric follows in the footsteps of other such evaluative rubrics, providing a structure for measuring the quality of something and whether it is "good enough" (Davidson, 2005).

Using a rubric also assumes that a complex entity (such as a physics teacher education program) may be represented in terms of a number of discrete elements (in this case, the elements of the PTEPA Rubric) and that

Local physics teacher community members with make-and-take demonstrations. ROWAN UNIVERSITY

the quality of those elements can be approximately measured through rating on a subjective scale. Evaluative rubrics have been demonstrated to be valuable for answering such questions of quality even in similarly complex situations (King, McKegg, Oakden, and Wehipeihana, 2013; Davidson, 2005; Allen and Tanner, 2006). Evaluative rubrics have also been employed in several other projects, such as the Teacher Education Program Assessment (TEPA; Coble, 2012), the PULSE rubrics (Aguirre et al., 2013), and several program accreditation and review processes (see Appendix A4: "Accreditation Review").

The PTEPA Rubric project was initially informed by the PhysTEC project's Theory of Change (see Appendix A8). A Theory of Change is an illustration that describes how the desired change is expected to happen as a result of the project's intervention, outlining the underlying assumptions and processes associated with achieving a project's goals. It is a project-specific description (rather than a general theory) and enables effective planning of project activities and assessments. The PhysTEC Theory of Change provides a hypothesized trajectory of a physics teacher education program toward a sustainable program that prepares many highly qualified physics teachers—that is, a thriving program.

In this hypothesized trajectory, a department engages in physics teacher education, generating an immediate sense of urgency and attention to the issue, and local leaders are empowered to undertake program activities. In the medium-term, this activity leads to enabling *structures* for physics teacher education (such as certification pathways), a supportive *climate* for physics teacher education (such as institutional commitment and collaboration), and effective *leadership*. The PTEPA Rubric was initially developed in part to measure the extent to which these medium-term outcomes (structures, climate, and leadership) are achieved at individual programs and validate this proposed trajectory toward sustainable teacher production (though the specific elements assessed by the PTEPA Rubric have evolved since the development of the Theory of Change). Note that while the Theory of Change was developed for the PhysTEC project, a thriving program that is not associated with PhysTEC could also follow a similar trajectory with different inputs allowing them to achieve these outcomes.

Rubric Structure

Early drafts of the PTEPA Rubric were informed by existing statements of common features of thriving physics (or science) teacher education programs. The first draft was based on the Teacher Education Program Assessment (TEPA), and the PTEPA Rubric retains some overarching categories that mirror those in the TEPA. The PTEPA Rubric was later structured in a format influenced by the Council for the Accreditation of Educator Preparation (CAEP) Evaluation Rubric (Council for the Accreditation of Educator Preparation, 2016), using the language and structure of "standards" and "components," narrative descriptions of those standards and components, and examples of attributes "below," "meeting," and "above" a sufficient level for each item.

Successive versions of the PTEPA Rubric were reconciled with the PhysTEC Key Components,[1] the report of the Task Force on Teacher Education in Physics (T-TEP; Meltzer, Plisch, and Vokos, 2012), and several reports on strong physics programs and career preparation (listed in Appendix A5: "Review of Related Reports"). However, the most significant effort in developing the PTEPA Rubric went toward shaping the rubric to represent what researchers observed at the eight diverse thriving programs in the study (see "Thriving Program Visits," below). Development of the structure of the rubric was a significant effort, with items, components, and standards iterated over many versions to find an organization that was meaningful yet not unmanageably long.

Items and Scale Points

The PTEPA Rubric development required identifying (1) the dimensions or criteria of performance to be measured, called "items," and (2) the levels of achievement on those items, called "scale points" (King, McKegg, Oakden, and Wehipeihana, 2013; Davidson, 2005; Oakden, 2018). The PTEPA Rubric represents what is called an "analytic rubric," where the levels of achievement are described quite specifically for each level of each item (Allen and Tanner, 2006), which is in contrast to a holistic or generic rubric in which a single generic scale is used across all items to describe high or low performance.[2] The choice of an analytic rubric is intended to increase the reliability of ratings; however, as has been acknowledged by other authors, it also adds a layer of complexity and challenge in rubric development (Oakden, 2018; Allen and Tanner, 2006; King, McKegg, Oakden, and Wehipeihana, 2013). The PTEPA Rubric uses three scale points per item. Originally five levels of achievement were developed, but this was found to be overly complex; the final decision of three levels (with the middle level denoting a "sufficient" level) was found to be more usable and is in alignment with Bresciani, Zelna, and Anderson (2004), who indicate that it is harder for a reader to make sense out of more than three levels. Additionally, three levels is a typical number for evaluation rubrics (see Appendix A4).

PTEPA Rubric items were initially drawn from the Teacher Education Program Assessment (TEPA), and the PTEPA Rubric retains many individual items that originated with the TEPA (e.g., "Institutional mission of teacher education," "Boundary crossers"). Other rubric items were added from other instruments, suggested by consultation with experts, and indicated by program observations. Researchers attempted to reconcile features that were suggested by these different sources with items on the rubric. When features from various sources reinforced one another, researchers prioritized including such an item on the rubric; when features did not correspond (e.g., a particular type of course was named as important at one program, but experts indicated that this situation was an anomaly), researchers considered whether that feature might not be included on the rubric. A detailed history of the development of many PTEPA Rubric items appears in Appendix A6: "Item History."

For each of the PTEPA Rubric items, researchers identified concrete hallmarks of the levels at which a program may exemplify that feature; these are the Developing, Benchmark, and Exemplary levels. In addition, "Not Present" indicates the item is absent from the program. The purpose of the scale points is to illustrate different levels of achievement for each item in specific, well-defined terms and to set expectations for what constitutes strength in each item. The description of each level is below.

Level	Description
Not Present (NP)	Item is not present in the program.
Developing	The program performs better than a typical U.S. institution of higher education on that item.
Benchmark	The program performs at a recommended level on that item.
Exemplary	The program is among the best-performing on that item.

The “Developing” level was constructed to be achievable by many physics teacher education programs; “Benchmark” is designed to represent satisfactory achievement, and the “Exemplary” level is meant to represent an ambitious yet realistic goal for the item. Where possible, scale points are both unidimensional and objective, and they progress somewhat linearly from level to level. For example, the scale points for “PTE program leaders” (item 2A-1) are:

- **Developing**: Program leaders include at least one faculty member.
- **Benchmark**: Program leaders include at least two faculty members.
- **Exemplary**: Program leaders include three or more faculty members.

In other cases, the scale points represent more complex situations but still frame things as a progression. For example, the scale points for “University-level support for STEM education” (item 1A-1) are:

- **Developing**: President- or provost-level administration verbally prioritizes STEM educational improvements, but as yet there is little to no evidence of this support.
- **Benchmark**: Additionally, there is evidence of university support for STEM education improvements.
- **Exemplary**: There is concrete support from the university for STEM education improvements.

In several cases, the scale points use technical language that is defined along with the item. For example, a footnote to item 1A-1 clarifies that “Evidence of support for education could encompass regular inclusion in strategic planning, public declarations of need for programs or educational change, verbal protection of the program,” and other possible features.

Standards and Components

The PTEPA Rubric is organized into six standards: (1) **Institutional Commitment**, (2) **Leadership and Collaboration**, (3) **Recruitment**, (4) **Knowledge and Skills for Teaching Physics**, (5) **Mentoring and Professional Support**, and (6) **Program Assessment.** Each standard has three or four components within it that address specific subtopics, and each component has two to eight individual items. The ordering of the standards represents a progression from the foundations of a physics teacher education program (institutional setting and program leadership) through a prospective teacher’s experiences (recruitment, student learning, and mentoring), and finally reflection on the program (assessment). Standards and components in the instrument typically represent broader program objectives, whereas items represent more concrete programmatic structures, policies, or actions. Where possible, the items represent directly measurable entities, and achievement of components or standards may be indirectly inferred by the degree of achievement of the items grouped under them.

To avoid repetition across standards, we often disaggregated separate aspects of items so they could appear in the most appropriate standard. For example, Learning Assistant programs have multiple aspects; we placed “Teaching/Learning Assistant participation” within **Standard 4: Knowledge and Skills for Teaching Physics** (measuring the number of future physics teachers who actually benefit from the experience for improving their teaching skills), but we placed “Availability of early teaching experiences” in **Standard 3: Recruitment** (acknowledging that how broadly available these experiences are is a measure of their ability to draw students into teaching).

THRIVING PROGRAM VISITS

Selection of Thriving Programs for Study

Physics teacher education programs selected for this study were *thriving* programs, defined as programs at large universities that typically graduate five or more highly qualified physics teachers in a year. Thriving programs are a subset of programs that belong to the “5+ Club,” an honor that PhysTEC awards to physics teacher education programs that graduate five or more teachers in any given year. At the time of the study, there were 27 programs in the 5+ Club. To select programs for this study, the list of programs in the 5+ Club was narrowed to exclude programs at small institutions or programs that met the 5+ Club criteria in only one year. From the remaining programs, eight were selected to represent the diversity of thriving physics teacher education programs. Half of the studied programs had received PhysTEC funding and half had not; including non-PhysTEC sites helped ensure validity of the rubric for all thriving programs by (1) avoiding circular logic (since PhysTEC sites are required to address the Key Components in their programs, including only PhysTEC sites might have led to the rubric resembling the Key Components) and (2) broadening the item pool (including non-PhysTEC sites helped to identify

Future teachers collect data using photogate sensors. TWAY PHOTOGRAPHY

items that were not part of the PhysTEC model). Additionally, the programs had a wide variety of structures (e.g., undergraduate programs, post-baccalaureate programs, UTeach replication programs, programs run by a single faculty leader, programs run by a large multidisciplinary team, and so on). The physics teacher education programs represented in this study are listed below, with PhysTEC sites indicated with an asterisk (see Chapter 4 for more description of these programs):

University of Texas at Austin

University of Colorado Boulder*

Brigham Young University

California Polytechnic University, San Luis Obispo*

Georgia State University*

Rowan University*

Rutgers University

Stony Brook University

Methods of Data Collection

For each program, the researcher completed the PTEPA Rubric by conducting a series of interviews with program personnel. For a given program, the series of interviews might have included faculty leaders, program staff, physics teacher candidates, Teachers in Residence, administrators, cooperating teachers, program graduates, and whoever else would have a perspective on the items in the PTEPA Rubric. Program visits were conducted either through intensive two-day in-person program visits (three programs) or two-day "remote program visits," consisting of a series of concentrated interviews by telephone and videoconference (five programs). PhysTEC-funded programs were prioritized for all in-person program visits to better justify the use of PhysTEC program resources. In either case, interviews were guided by extensive protocols (see Appendix A2). Researchers documented the interviews with detailed notes pertaining to each rubric item and component, with special attention to the evidence justifying the rating on each item and triangulation of that evidence among multiple interviewees.

Multiple Purposes of Program Visits

The program visits served multiple purposes, including instrument development, initial validation, collection of data supporting research findings, documentation of strongest elements and common challenges, and case study development.

- **Iterative development of the PTEPA Rubric.** A primary purpose of the program visits was to inform iterative development of the PTEPA Rubric. Researcher observations of programs supported identification of many potentially important program features, which researchers strove to reconcile with the features represented on the rubric at the time of the program visit. For example, when a program visit revealed important features not included on the rubric, researchers considered adding an item or component to characterize that feature. Similarly, if few of the studied programs exhibited a specific element of the rubric, researchers considered removing that element.

- **Initial validation of the PTEPA Rubric.** The program visits contributed to content validity and face validity of the instrument, as described in the "Validation of the PTEPA Rubric" section below.

- **Collection of data supporting initial research findings.** Data from the program visits forms the basis for the research findings documented in this report, which are summarized in Chapter 3.

- **Documentation of strongest elements and common challenges.** In addition, program visits identified how different physics teacher education programs embody the various PTEPA Rubric standards (see Chapter 4). Finally, the program visits showed some of the challenges that programs face in addressing the PTEPA Rubric standards (see Chapter 5). Highlights, challenges, and case studies were systematically reviewed by program leaders for fact-checking and validation of conclusions.

- **Case study development.** Reports from each of these program visits are documented in Appendix A3: "Case Studies of Thriving Programs," providing an in-depth understanding of each program at the time of the visit.

VALIDATION OF THE PTEPA RUBRIC

Like all validation, the validation of the PTEPA Rubric is hypothesis-specific. In this study, validation efforts investigate the hypothesis that *the PTEPA Rubric measures features that thriving programs tend to have*. As an analogy, we might liken the PTEPA Rubric to a "Health Rubric" that elucidates healthy lifestyle behaviors such as nutrition and exercise, and we might compare a high teacher graduation rate to a healthy weight; in this analogy, the hypothesis would be that the "Health Rubric" measures behaviors that people at a healthy weight tend to have. A variety of additional potential hypotheses regarding the PTEPA Rubric are listed in Chapter 7: "What Should Come Next?"

Table 1 details several types of validity and describes specifically how the PTEPA Rubric has demonstrated this type of validity. For some types of validity, future investigations are planned.

Alignment with Other Instruments and Literature

Alignment with relevant instruments and research findings supports several types of validity of the instrument: *Substantive validity* describes the quality of the theoretical basis for the features thought to be important for thriving physics teacher education programs, and *content validity* describes the extent to which the instrument has all the features thought to be important for thriving programs. The PTEPA Rubric is based on and aligned with other validated instruments, and thus it inherits the substantive and content validity of those instruments. In addition, the PTEPA Rubric has been

Table 1. Types of validity and associated validation processes for the PTEPA Rubric.

Type of Validity	PTEPA Rubric Validation	Where Described
Substantive Validity Is there a good theoretical basis for the features thought to be important for thriving physics teacher education programs?	The PTEPA Rubric is based on other validated instruments and inherits the substantive validity of those instruments.	This chapter: "Alignment with Other Instruments and Literature" Appendix A5 Appendix A6
Content Validity Does the PTEPA Rubric include all the common features that we think are important for thriving programs?	The PTEPA Rubric is aligned with other validated instruments and inherits the content validity of those instruments. The PTEPA Rubric has been reconciled with researcher observations, program leaders' knowledge, literature, and reports of thriving physics teacher education programs.	This chapter: "Alignment with Other Instruments and Literature" This chapter: "Identification of Prevalent Items" This chapter: "Thriving Program Visits" Appendix A3 Appendix A5 Appendix A6
Face Validity Does the PTEPA Rubric appear to measure the features that thriving physics teacher education programs tend to have?	The PTEPA Rubric has been reviewed by experts in physics teacher education and physics teacher education program leaders.	This chapter: "Expert Review" This chapter: "Thriving Program Visits" Appendix A3 Appendix A5
Reliability Does the PTEPA Rubric work for self-study as well as when used by trained observers?	Planned activity: Compare program leader rubric ratings to those of trained observers.	This chapter: "Thriving Program Visits" Chapter 7 Appendix A3
Process Validity To what extent do program leaders understand the PTEPA Rubric items as they are intended?	Planned activity: Interview program leaders as respondents on their interpretation/understanding of rubric items.	Chapter 7
Consequential Validity To what extent are PTEPA Rubric results used in ways that improve local programs?	Planned activity: Interview program leaders on their programs' response to rubric evaluation.	Chapter 7
Criterion Validity, Concurrent and Predictive Do different PTEPA Rubric results (1) correlate with and (2) predict different rates of physics teacher production?	Planned activity: Apply the PTEPA Rubric to thriving and non-thriving programs and correlate PTEPA Rubric results with teacher production.	Chapter 7

extensively reconciled with relevant literature and reports along with researchers' observations of, and program leaders' knowledge of, thriving physics teacher education programs.

For example, the Teacher Education Program Assessment (TEPA; Coble, 2012), which formed the initial basis for the PTEPA Rubric, was developed through extensive expert feedback and program visits. The TEPA includes many standards and components similar to those in the PTEPA Rubric, including "Leadership," "Recruitment," "Content and Pedagogy," "Beginning Teacher Support," and "School Development." The PTEPA Rubric is also well aligned with the Task Force on Teacher Education in Physics (T-TEP) report (Meltzer, Plisch, and Vokos, 2012) and the associated policy statement,[3] which highlight the areas of collaboration, pedagogy, recruitment, and beginning teacher support as important for physics teacher preparation. The PTEPA Rubric components also correspond well with the PhysTEC Key Components. All of these alignments are documented specifically in Appendix A5. It is worth noting that the PTEPA Rubric was not explicitly developed to directly align with any of the other reports or instruments in Appendix A5 except the TEPA and the Key Components, and it was significantly restructured from the template suggested by the TEPA. The fact that the PTEPA Rubric essentially "rediscovered" many elements recommended in these other sources provides some validation for the components and organization of the instrument.

The areas in which the PTEPA Rubric does not align with other instruments are often specific to *physics* teacher education programs. The areas in the TEPA that do not appear in the PTEPA Rubric are almost entirely within the domain of schools of education or teacher certification, which the PTEPA Rubric explicitly avoids (except in areas such as student teaching, where *physics*-specific support is the focus). Similarly, since the PTEPA Rubric is focused on supporting increased numbers of physics teachers, elements of early teacher support are only minimally included (within **Standard 5: Mentoring and Professional Support**) even though such aspects are important for career development and retention.

Additional evidence for the substantive and content validity of the PTEPA Rubric is presented in Appendix A5 and Appendix A6.

Identification of Prevalent Items

Further evidence of the content validity of the PTEPA Rubric derives from identification of individual items in which many thriving programs are strong. These items are denoted as "Prevalent" items. Prevalent items are those for which (1) at least six of the eight studied programs were rated at least at Benchmark level, and (2) at least one of the following confidence measures is met (to strengthen reliability):[4]

- The item is inherently reliable because it measures an objective quantity, such as the number of faculty leaders or Teachers in Residence.
- At least six of the eight studied programs were rated Exemplary on that item.
- Both members of two pairs of very different types of programs were rated at least Benchmark on that item, indicating that the item is important across contexts (e.g., at both a large STEM teacher education program run from outside the physics department and a small program led by a single physics faculty member).

Appendix A7: "Item Strength and Prevalence Chart" shows every PTEPA Rubric item according to the percentage of each item rated at each level (with Prevalent items marked), and it serves to support the validity of this approach.

Prevalent items might indicate these activities are more necessary for a thriving program or might indicate the items are relatively easy for programs to achieve. Some items (see Appendix A7) have low ratings at the studied programs, suggesting that even thriving programs have less success in these areas. This may indicate that these items are less essential to a thriving program or that they are very difficult to achieve. For complete documentation of performance on PTEPA Rubric items, see Appendix A6.

Expert Review

Face validity of the PTEPA Rubric describes the extent to which the PTEPA Rubric appears to experts to measure the features that thriving physics teacher education programs tend to have. The PTEPA has been scrutinized by national experts in physics teacher education, including the PhysTEC leadership team, members of the National Task Force on Teacher Education in Physics, the leaders of the thriving programs studied in this report, and researchers who study physics teacher education (see Acknowledgments). These experts raised important questions that influenced revision of the PTEPA Rubric at many stages, from the scope of the instrument to addition and clarification of individual rubric items.

Table 2. PTEPA Rubric items, components, and standards with SDI values that are significantly lower than the average.

Items	Components	Standards
2B-4: Personal motivation to improve PTE **2B-6**: K–12 school engagement **2B-8**: Professional engagement in PTE **3A-1**: Physics majors **3B-2**: Physics teaching ambassador SDI value for these items is 0; all programs achieved Benchmark level for these items.	**2B**: Program Team Attributes **3A**: Recruitment Opportunities Most programs were rated Benchmark for most items in these components.	**2**: Leadership and Collaboration As shown in Figure 5 in Chapter 3, there is a high number of items at Exemplary level in this standard.

Variability in Rubric Ratings

In applying the rubric to thriving programs, we observed wide variability in the strength of specific components within the larger standards (see Figure 6 in Chapter 3). For example, program ratings on components within Standard 1 range from strong to average to less strong. Because a program can show highly variable performance on elements within a standard, this suggests that (1) a cluster analysis may not validate the components as being considered as part of a larger standard and (2) a component-level (rather than standard-level) analysis may be particularly important for characterizing programs.

Additionally, in order to characterize the level of variability in ratings across the PTEPA Rubric, we made use of a measure from ecology, Simpson's Diversity Index (SDI).[5] We used the SDI to quantify the diversity of PTEPA ratings for each item, component, and standard; those that are dominated by one or two ratings (e.g., most are at Exemplary or Benchmark level) are considered less diverse than those with a more even distribution of rating levels (e.g., equally distributed across NP, Developing, Benchmark, and Exemplary). In our case, the SDI measure ranges from 0–0.75, with lower values representing ratings that are less diverse (i.e., clustered in one or two levels). Thus, if items on the PTEPA Rubric had an SDI close to 0, that would suggest that all item ratings were clustered on a single level (e.g., all Benchmark). An SDI of 0.75 would indicate that item ratings were equally distributed across all four rating levels (two programs per level).

The average SDI of PTEPA Rubric item ratings is 0.50; the SDI of components is 0.60, and the SDI of standards is 0.63. Most SDI values are close to these averages. These results suggest that all the levels, from NP to Exemplary, tend to be represented in our items (as well as components and standards). This finding can also be seen visually in Figure 3 in Chapter 3. Another symptom of this spread of responses is that there are no items, components, or standards that are particularly *high* on the SDI scale (all are within two standard deviations of the average), and thus no items, components, or standards are much more evenly distributed across the rating categories than others.

However, certain items, components, and standards have standardized SDI scores that are more than two standard deviations *lower* than the average. These are the PTEPA Rubric elements for which program ratings tend to be clustered on one or two levels (in our case, at high levels). These are listed in Table 2.

Thus, we find that PTEPA Rubric ratings in general are quite spread out across the four available levels, with certain exceptions that are tightly clustered on the Benchmark or Exemplary rating. This suggests that it is possible to discriminate amongst different program approaches on PTEPA Rubric items, components, and standards. Further, this result indicates that on these tightly clustered items, the PTEPA Rubric is less able to identify more fine-grained differences among programs.

ETHICS

Throughout development and validation of the PTEPA Rubric, the personnel on this project have striven for the highest ethical standards to protect the welfare and dignity of all stakeholders, as articulated in the American Evaluation Association's "Guiding Principles for Evaluators."[1] In particular, personnel have:

- Abided by **human subjects research** protocols, including using informed consent, protecting the confidentiality of data collected at the study sites, and publicly reporting only particular strengths (and not limitations) at any program studied.
- Maintained **integrity and professional ethics**, ensuring that findings and outputs are justified by the data and meet the needs of the our client (the American Physical Society), while also attending to the needs and welfare of the broader physics teacher education community and principles of high-quality research.
- Sought to **reduce any potential risk** or harm due to the collection of PTEPA Rubric data by protecting the privacy of study participants, considering broad implications of the instrument and its use, and emphasizing that rubric results are not to be over-interpreted (e.g., numerical scores are not to be assigned to scale points, a program does not achieve a "score" on the rubric, and the rubric is intended to be used only for self-assessment rather than external review).
- Sought to foster **social equity** by creating supports for using the rubric effectively and for data visualization of the results so that those contributing to the work (namely the study sites and future participants) can also benefit.
- Sought to include the **range of relevant perspectives** of the stakeholders in the work by interviewing experts, researchers, students, alumni, program leaders, administrators, Teachers in Residence, and so on.
- Considered **contextual elements**, such as institutional characteristics and local factors, to ensure a comprehensive understanding of context.

SUMMARY

This study has identified elements of thriving physics teacher education programs through an extensive development and validation process that resulted in the PTEPA Rubric. Development activities have included theoretical development, adaptation of related instruments, and studies of thriving physics teacher education programs. Sources of validation have included researcher observations, program leaders' knowledge, literature and reports of thriving physics teacher education programs, and expert review. This systematic development and validation has produced an instrument that reflects the practices and priorities of diverse thriving physics teacher education programs.

ENDNOTES

1 Retrieved online at http://phystec.org/keycomponents.

2 Note, however, that we do suggest using a generic rating scale for programs to determine the extent to which they have achieved satisfactory performance on each standard as a whole as well as a self-rating of the importance of each aspect of the PTEPA Rubric for their program (see Appendix A2: "Resources for Using the PTEPA Rubric"), in accordance with Oakden's (2018) recommendation.

3 See the T-TEP policy statement at https://www.phystec.org/webdocs/TaskForce.cfm.

4 Exceptions were made for certain items, such as "Streamlined undergraduate teaching track in physics" (item 3D-1), which is not relevant where there is no undergraduate physics teacher education program. In those cases, five out of the six programs with undergraduate certification pathways were required to meet at least Benchmark level on the item to be considered Prevalent.

5 In ecology, SDI provides a measure of the number of species present in an area (more information and the formula for SDI can be found at http://www.countrysideinfo.co.uk/simpsons.htm). An area dominated by a few species is considered to be less diverse than one in which several different species have a similar abundance: SDI = 1 - Σ (n/N)^2. We subtracted the value from 1 so that elements with the least variability have low SDI values. Our "species" are the ratings available (i.e., NP, Benchmark, Developing, and Exemplary). The number n represents the total number of observations of any of the four levels (such as Developing), and "N" is the total number of ratings collected. For an individual item, *n* is the number of times any single level (such as Developing) is observed within that item, and N=8 for all institutions. For a component, *n* is the count of the number of observations of any single level within that component, and N=8 * the number of items in a component for a particular component. A similar calculation is used for a standard.

6 See http://www.eval.org/p/cm/ld/fid=51.

CHAPTER 3

What Has Been Learned About Thriving Programs?

Data gathered from the eight thriving teacher education programs (based on the PTEPA Rubric) support some early conclusions about common practices at these programs as well as differences among them.

INTRODUCTION

Preliminary data has been gathered using the Physics Teacher Education Program Analysis (PTEPA) Rubric at eight thriving physics teacher education programs (large programs consistently producing five or more physics teachers per year).

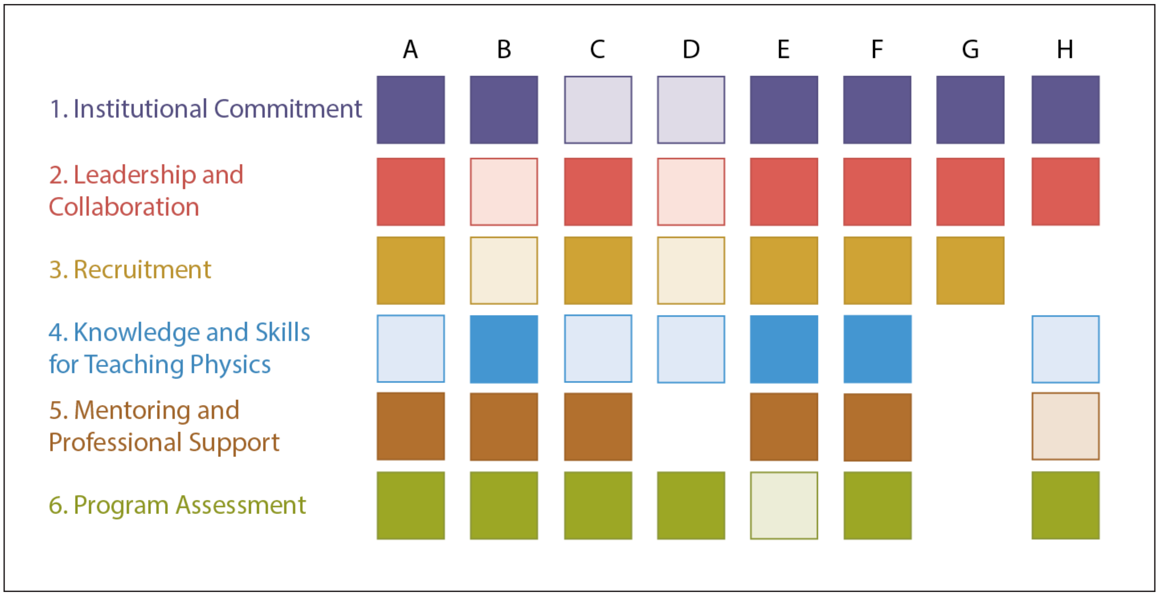
The findings shared in this chapter are correlational; research has not yet determined whether these features of the data predict high graduation rates of future physics teachers. Nevertheless, the findings offer some guidance for physics teacher education programs as well as for future development of the rubric. In what follows, programs are labeled anonymously (with letters A–H).

FINDINGS

1. Thriving programs are strong in multiple standards.

The thriving programs studied so far are strong in multiple standards, suggesting that a broad range of high-quality activities are occurring in those programs rather than a narrow set of strategies. Figure 2 shows which programs had a majority of items in each standard rated as Exemplary (fully shaded box) or Benchmark or higher (lightly shaded box). As shown within the columns of Figure 2, seven of the eight studied programs have a majority of items in at least five standards rated as Benchmark or higher (A–F and H), and five programs have a majority of items in *every* standard rated as Benchmark or higher (A–C, E–F). Many programs also have a majority of items in multiple standards rated as Exemplary.

Figure 2: Thriving programs are strong in multiple PTEPA Rubric standards.



Strength of different thriving physics teacher education programs (A–H) in each of the six standards of the PTEPA Rubric. A fully shaded box indicates that the majority of items (>50%) in that standard were rated as Exemplary. A lightly shaded box indicates that a majority of items in that standard were rated at least Benchmark (i.e., Benchmark or Exemplary). If the cell is empty, then neither of these criteria was met (i.e., a majority of the items were rated Developing and/or Not Present).

The PhysTEC-supported sites are programs C, D, E, and G. There is no obvious distinction between PhysTEC-supported and non-PhysTEC-supported programs based on this early data.

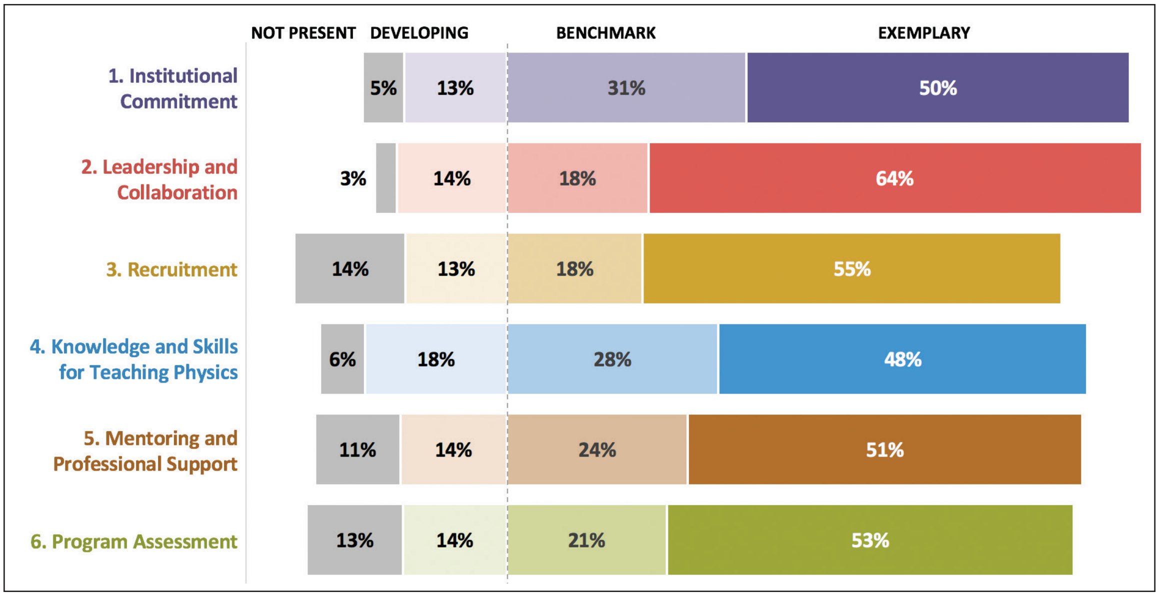
2. Thriving programs are most consistently strong in **Standard 1: Institutional Commitment** and **Standard 2: Leadership and Collaboration.**

As shown within Figure 2, the eight thriving programs studied are most consistently strong in the first two standards. Six programs achieved a majority of the items at the Exemplary level in these standards, and the other two programs achieved a majority of the items at the Benchmark level. This result implies that what the PTEPA Rubric measures in these areas—institutional commitment, leadership, and collaboration—may be particularly important for teacher preparation. **Standard 1: Institutional Commitment** includes measurement of institutional climate and support, analysis of the reward structure for leadership in physics teacher education, and identification of program resources such as staff, funding, and space. **Standard 2: Leadership and Collaboration** includes the examination of the number of program team members and descriptions of their attributes as well as the documentation of effective collaboration between academic units (e.g., physics and education).

The data displayed in Figure 2 shows **Institutional Commitment** and **Leadership and Collaboration** to be equally strong. Figure 3, which shows all the ratings for all items at all studied programs together, suggests that **Leadership and Collaboration** may be slightly stronger for thriving programs considered as a group; 64% of its items are rated Exemplary (aggregating results from all thriving programs studied) compared to 48–55% of the items in the other standards.

If we consider instead the number of programs that achieve at least Benchmark status (i.e., the sum of all the Benchmark and Exemplary ratings), then Standards 1 and 2 are both strong, with 81% and 82% of items rated with at least Benchmark level respectively. The other standards have 73–76% of items rated with at least Benchmark level; however, as will be discussed later, the components within these standards are not all achieved at a uniformly high level.

Figure 3: Thriving programs are most consistently strong in the first two PTEPA Rubric standards.



Percentage of PTEPA Rubric items in each standard that were rated Not Present, Developing, Benchmark, and Exemplary at the studied programs.

3. Different thriving programs are strong in different standards.

Different thriving physics teacher education programs are strong in different PTEPA Rubric standards. The pattern of majority-Exemplary or majority-Benchmark items is different for every program (no two columns of Figure 2 are the same), suggesting that different thriving programs embody different patterns of physics teacher education activity and structures. Highlights of the activities that take place in specific programs are outlined in Chapter 4 of this report.

Five of the thriving programs studied (A, B, C, E, and F) are strongly rated across all standards, whereas the other thriving programs studied (D, G, and H) have less uniformly positive ratings across the PTEPA Rubric; this shows that even among thriving programs, there is great variety in the strength of particular standards. There is no single standard in which all the thriving programs studied had a majority of items rated as Exemplary (no row of Figure 2 is fully shaded), meaning that there is little basis to attribute these programs' success to any one standard.

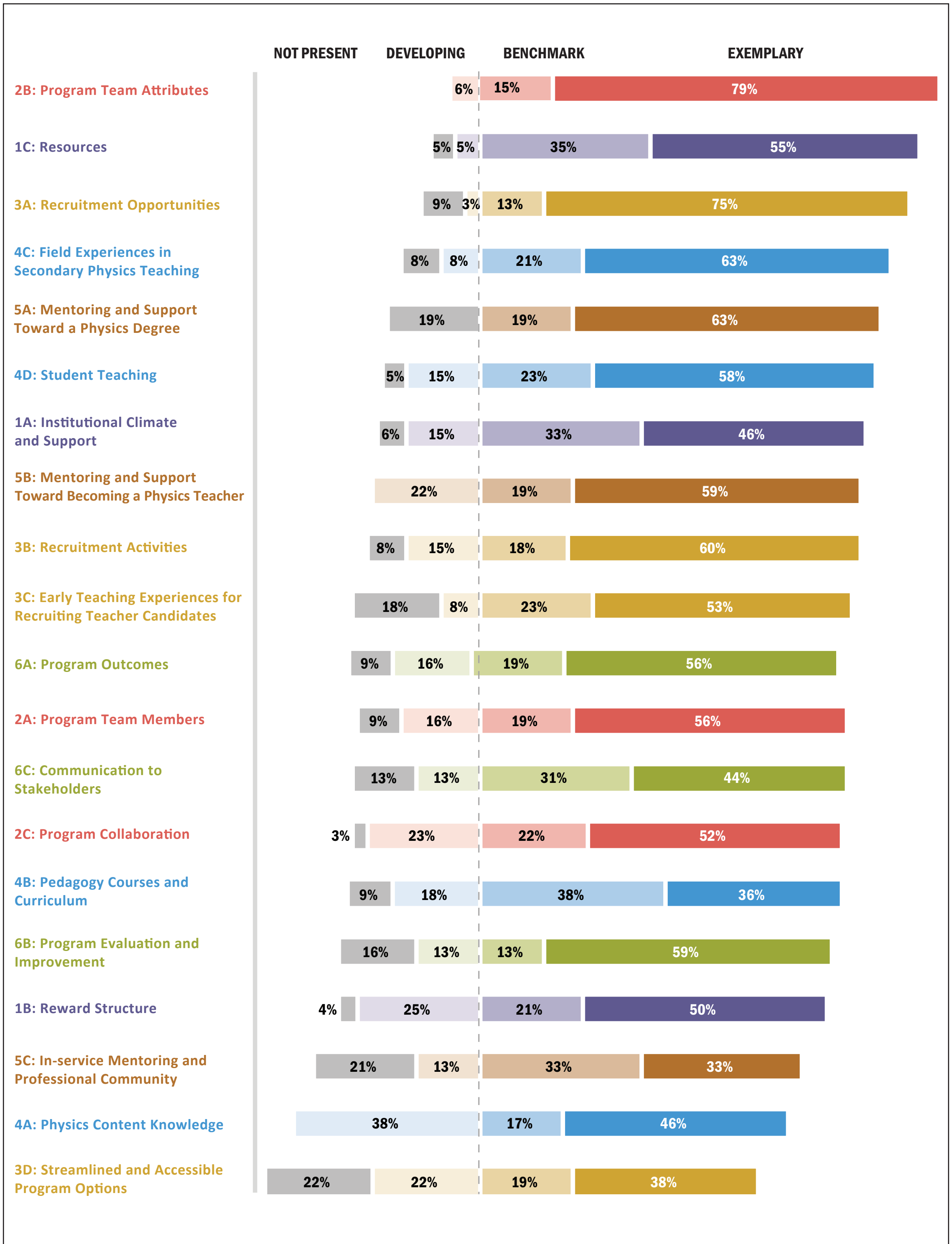
These results are further strengthened by the finding that program ratings on items, components, and standards in the PTEPA Rubric tend to be spread out across rating levels (see the discussion in Chapter 2 on characterizing variability in rubric ratings). Those items that are tightly clustered on Exemplary or Benchmark ratings may indicate prominent characteristics that are common among thriving programs.

4. Thriving programs tend to be strong in particular components.

If we examine all items within each component (in aggregate across the eight programs), we see that different components exhibit different levels of strength at the studied programs. In Figure 4, components are displayed in order according to the percentage of items rated with at least Benchmark level.

By this measure, top-rated components include *2B: Program Team Attributes*, *1C: Resources*, and *3A: Recruitment Opportunities*. Over 85% of the items within these components are rated with at least Benchmark level, suggesting that these components are particularly strong for these thriving programs as a group.

Figure 4: Thriving programs tend to be strong in particular components of the PTEPA Rubric.



Percentage of PTEPA Rubric items in each component that were rated Not Present, Developing, Benchmark, and Exemplary at the studied programs.

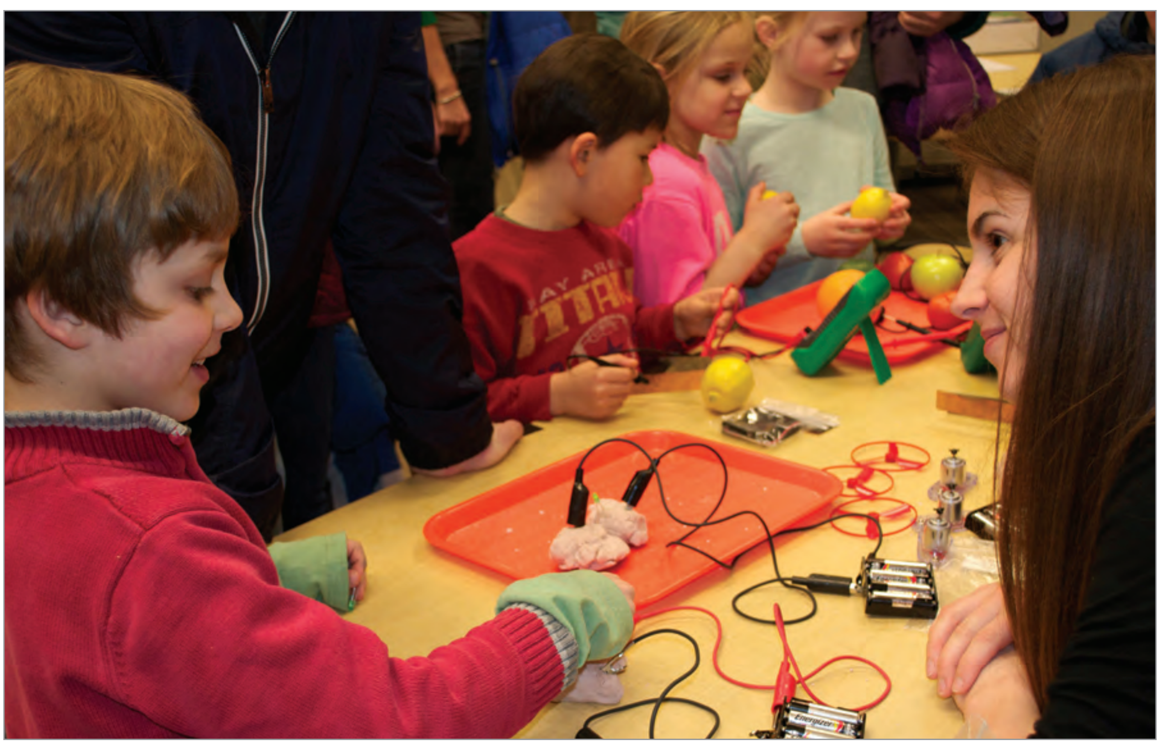
In contrast, other components seem to be less strong; fewer than 70% of the items within the components *5C: In-service Mentoring and Professional Community*, *4A: Physics Content Knowledge*, and *3D: Streamlined and Accessible Program Options* are rated with at least Benchmark level. This result suggests that even thriving programs have less success or highly variable practices in these areas, and this matches our observations from program visits (e.g., some programs do not have the resources to support strong alumni programs [5C], and pedagogical preparation [4B] takes many forms at thriving programs).

Figure 4 also suggests that there is wide variability in the strength of specific components within the larger standards. For example, components within Standard 1 appear toward the top, middle, and bottom of Figure 4, indicating that those components range from strong to average to less strong in the studied thriving programs taken together. This shows that strength in a given standard does not necessarily indicate strength in every component within that standard and suggests that a component-level (rather than standard-level) analysis may be more valid for characterizing programs.

5. Thriving programs are consistently strong in certain items, denoted as *Prevalent*.

Different items on the PTEPA Rubric exhibit different aggregated strengths across the eight studied programs. Strength in item ratings ranges from items in which all eight programs are rated Exemplary to items in which only two or three programs are rated Benchmark or above (see Appendix A7 for a list of all rubric items sorted by relative strength across the studied programs). Items with the most consistently strong ratings across the eight studied programs are identified as *Prevalent* (see Table 3). The criteria used to select items as Prevalent were (1) at least 75% (six) of the studied programs were rated with at least Benchmark level in that item, and (2) at least one of three confidence measures was met to ensure reliability (see Chapter 2).[1]

The list of Prevalent items (Table 3 below) serves as a possible focal point for program improvement. Their high frequency of occurrence among thriving programs suggests these items may be particularly important for success in preparing large numbers of physics teachers.



Future teachers lead STEM activities at an outreach event. UNIVERSITY OF COLORADO BOULDER

Table 3. Prevalent items in the PTEPA Rubric.

Standard 1: Institutional Commitment	
1A-1	University-level support for STEM education
1A-2	Institutional mission of teacher education
1A-3	Administrative recognition for physics teacher education (PTE) program
1C-1	Engaged staff
1C-2	Institutional funding
1C-3	External funding
Standard 2: Leadership and Collaboration	
2A-1	PTE program leaders
2A-2	PTE program team
2A-3	Teacher in Residence (TIR)
2B-1	Common vision among the PTE program team
2B-2	Positional power
2B-3	Disciplinary expertise
2B-4	Personal motivation to improve PTE
2B-5	Integration of Teacher in Residence (TIR)
2B-6	K–12 school engagement
2B-7	Physics Education Research (PER) expertise
2B-8	Professional engagement in PTE
2C-1	Communication across units on PTE program elements
2C-2	Negotiated roles between units
2C-3	Boundary crossers
2C-4	Collaboration with PTE mentor on student teacher placement
Standard 3: Recruitment	
3A-1	Physics majors
3A-2	Physics-aligned majors
3B-1	Physics teaching advisor
3B-2	Physics teaching ambassador
3B-3	Accurate information about career benefits of teaching
3C-1	Attractiveness of early teaching experiences
3C-2	Exposure to intellectual challenge of teaching
3D-1	Streamlined undergraduate teaching track in physics
Standard 4: Knowledge and Skills for Teaching Physics	
4A-1	Physics degree for physics teacher candidates
4C-1	Number of cooperating physics teachers for field experiences
4C-2	Quality of field experiences
4C-3	Quality of field experience classrooms
4D-1	University supervisor collaboration with PTE team
4D-2	University supervisor experience
4D-3	Quality of cooperating teachers for student teaching
Standard 5: Mentoring and Professional Support	
5A-1	Student community in physics
5B-1	Advising of physics teacher candidates
5B-2	Mentoring of physics teacher candidates by a PTE mentor
Standard 6: Program Assessment	
6A-1	Annual graduation from PTE program
6A-2	Annual recruitment in PTE program
6B-1	Tracking program metrics
6B-2	Feedback from stakeholders
6C-1	Communication within the university
6C-2	Communication with university administrators

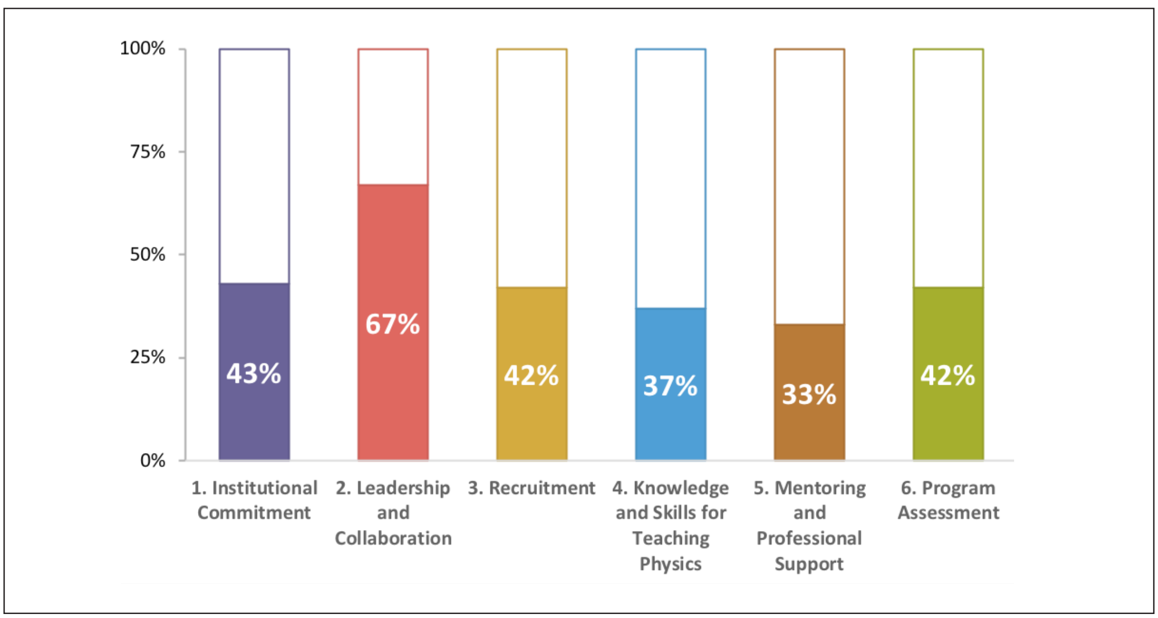
For complete documentation of performance on PTEPA Rubric items, see Appendix A7.

There are a few important caveats to be made about these items in Table 3:

- *Identification of Prevalent items depends on our selection criteria.* If the criteria were chosen slightly differently (e.g., requiring five instead of six programs to meet Benchmark level), the list of Prevalent items would change.
- *Identification of Prevalent items depends on the programs chosen.* Applying the rubric to a different set of thriving programs might result in a different list of Prevalent items.
- *Prevalent items should not be necessarily understood to be more important.* Some Prevalent items may simply be easier to achieve. Similarly, standards (or components) with many Prevalent items might be easier for programs to achieve. Items that are not denoted as Prevalent may be particularly important for certain types of programs but not others. Lastly, due to the correlational nature of the study, the Prevalent items may be commonly observed at thriving programs while having no causal relationship to teacher production.
- *This list of Prevalent items may be incomplete.* There may be additional items that have not yet been identified that would have met the Prevalent criteria had they been on the rubric. Also, some existing items may be more difficult to achieve as written and thus did not have sufficient strength across the studied programs to meet the selection criteria.

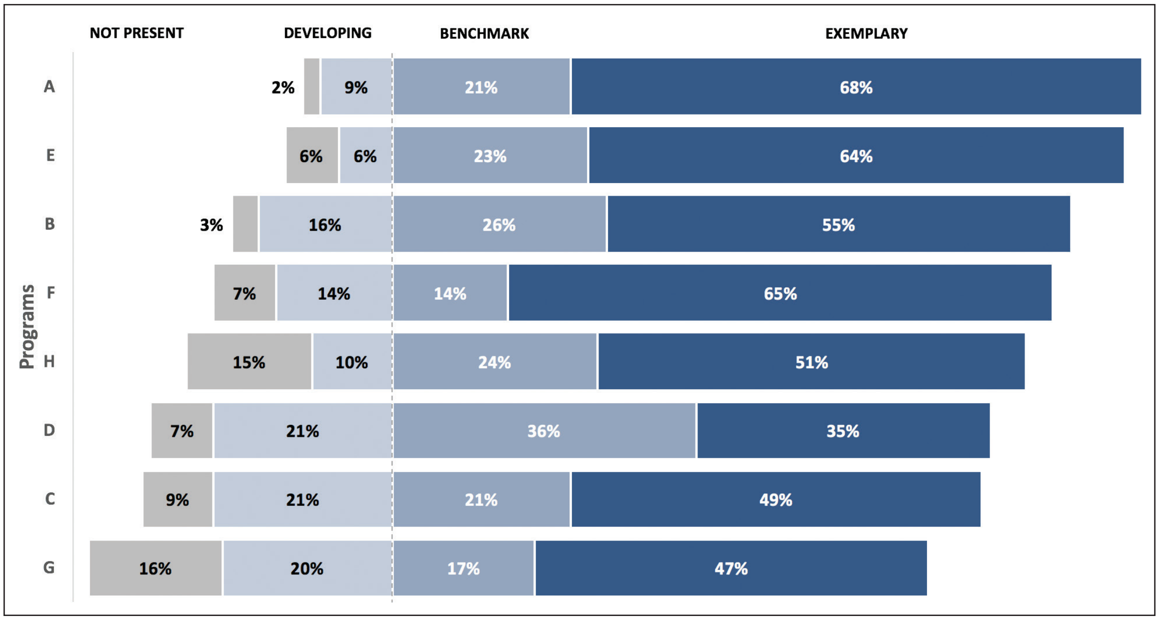
The number of Prevalent items varies by standard. Figure 5 shows the percentage of items within that standard that are Prevalent. In Standard 2, for example, 67% of the items are Prevalent, indicating that many thriving programs have an effective leadership team (which includes people whose positions, expertise, identity, and activities strengthen the program). This result is consistent with the findings of prior studies that emphasize the critical role of champions for physics teacher education (Meltzer, Plisch, and Vokos, 2012; Scherr, Plisch, and Goertzen, 2017). In contrast, **Standard 5: Mentoring and Professional Support** has only 33% Prevalent items, indicating that fewer programs have strong activity in these areas. However, these statistics should be interpreted with caution, as PTEPA Rubric

Figure 5: Item prevalence varies across standards.



Percentage of Prevalent PTEPA Rubric items in each standard (shaded part of the bar) compared to non-Prevalent items (unshaded portion of bar). For Prevalent items, at least 75% (six) of the studied programs are rated with at least Benchmark level in that item, and at least one of three confidence measures is met to ensure reliability (see Chapter 2).

Figure 6: Thriving programs are not strong on all items.



Percentage of all PTEPA Rubric items (across all standards) at each studied program that were rated Not Present, Developing, Benchmark, and Exemplary.

items do not have equal weight; some within a particular component or standard might be especially critical, and the caveats described above also apply to this analysis.

6. Thriving programs are not strong on all items.

At the item level, the thriving programs studied are not uniformly rated at Exemplary levels. In fact, all thriving programs had many items rated as Not Present or Developing. As shown in Figure 6, the eight thriving programs studied so far had up to 16% of items rated as NP and up to 21% of items rated as Developing. Among all the studied programs, the percentage of items rated Benchmark or higher ranged from 64–89%; the percentage rated Exemplary ranged from 35–68%.

Additionally, as shown in Figure 2 above, some thriving programs did not have a majority of items at Benchmark level within particular standards. This result suggests that not all of the PTEPA Rubric items (and perhaps not all standards) are essential for success in every physics teacher education program.

SUMMARY

Preliminary research using the PTEPA Rubric finds that thriving programs are strong in multiple standards, that they are most consistently strong in the first two standards, that they show variable performance among the components and items of each standard, and that over 40 items are identified as Prevalent among thriving programs. These findings may serve as a guide for physics teacher education programs and future PTEPA Rubric development.

ENDNOTES

1 A few items are only relevant to programs with an undergraduate certification option and thus did not apply to two of the studied programs. For those items, we required five out of the six remaining programs to meet at least the Benchmark level. Those items are all the items within components 3C, 4C, and 4D, plus 3D1 and 3D2.

CHAPTER 4

What Are Some of the Strongest Elements Observed at Thriving Programs?

Particular thriving programs exhibit specific strengths on the PTEPA Rubric; their practices and structures in each standard and component are outlined to serve as models for other programs.

INTRODUCTION

In the following sections, we outline how each thriving program achieved strength in the six Physics Teacher Education Program Analysis (PTEPA) Rubric standards. These practices reflect the program at the time of the program visit (see Appendix A3 for dates); in some cases, the program structures have changed since that time.

THRIVING PROGRAMS STUDIED

Below is the list of the eight thriving programs that were visited for development of the PTEPA Rubric and some detail about each program.

1. University of Texas at Austin (UTeach Austin)
A four-year program at a research-intensive university that is the flagship institution of the Texas state system. Students in UTeach earn a STEM degree and obtain their teacher certifications in a specialized program for STEM majors. UTeach Austin is the original UTeach program, which has been replicated at over 40 institutions.

2. University of Colorado Boulder (CU Boulder)
A self-contained, primarily undergraduate, STEM teacher licensure program and UTeach replication program (termed CU Teach) that was also a PhysTEC site, located at a research-intensive university that is the flagship institution of the University of Colorado system.

3. Brigham Young University
A program at a private religious university (led by a tenured physics faculty member who is also an expert secondary science teacher) in which an undergraduate physics degree is structured to lead to education licensure in physics or physical science.

4. California Polytechnic University, San Luis Obispo (Cal Poly San Luis Obispo)
A PhysTEC site at a technically focused public university in which physics and physics-aligned majors reach licensure in a one-year post-baccalaureate program in the School of Education and are supported throughout the process by an interdisciplinary STEM center.

5. Georgia State University
A recently funded PhysTEC site at an urban-serving university with a highly diverse student population, led by a physics faculty member, in which an undergraduate physics degree is coordinated with education licensure.

6. Rowan University
A PhysTEC-funded program at a former normal school in which physics majors work toward licensure either through a double major in physics and secondary education or a physics major followed by a master's degree in STEM teaching. (As of fall 2017, only the second option is available.)

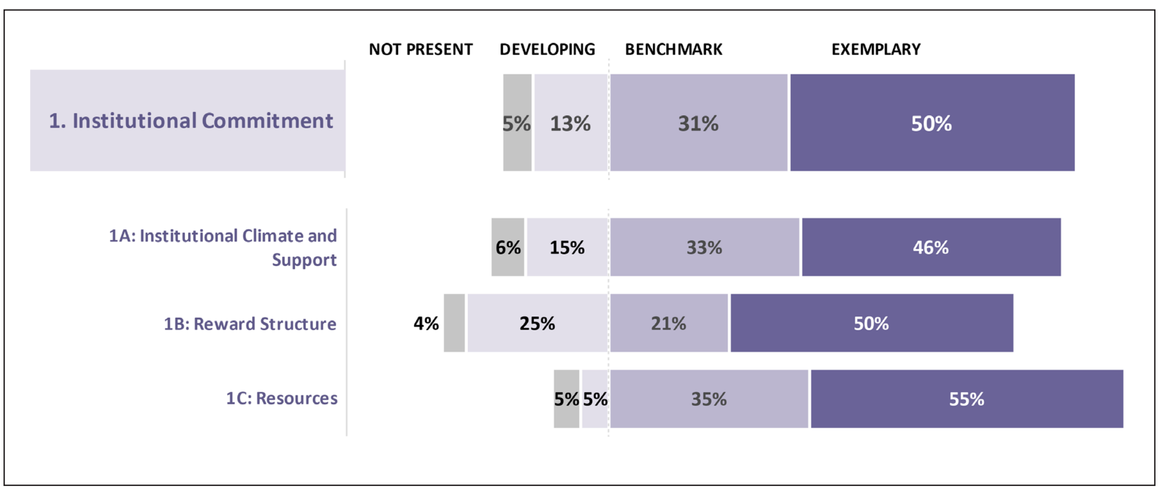
7. Rutgers University
A physics-focused master's program housed in the Graduate School of Education, led by an education faculty member with expertise in secondary physics teaching and physics education research.

8. Stony Brook University
A program at a research-intensive public university in which physics majors reach licensure in an 18-month post-baccalaureate program under the umbrella of an interdisciplinary STEM education center.

Standard 1: Institutional Commitment

Many thriving programs benefit from being a part of an institution that strongly supports teacher education, STEM education, and sometimes even STEM teacher education specifically. For example, teacher education might be recognized as part of the mission of the university or the College of Arts and Sciences, or it might be actively promoted by the administration, showing favorable **institutional climate and support (1A)**. Leadership in physics teacher education is encouraged, supported, and **rewarded by the institution (1B)**, and programs obtain the **resources they need to run it (1C)**. Figure 7 shows the performance of studied programs on this standard and its components.

Figure 7: Performance of studied programs on Standard 1.



The percentage of items within Standard 1 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 1A: Institutional Climate and Support

- At **UTeach Austin**, state laws require that teachers receive a degree in the discipline in which they will be teaching. To meet this mandate, the program was jointly created by the deans of Natural Science and of Education, who shared a vision for STEM-specific teacher preparation. The administration continues to offer tangible supports to demonstrate this commitment, such as approving new faculty hires, faculty lines devoted to teaching UTeach courses, and space for the program. The administration also allows UTeach students to make up exams if their teaching schedules conflict with the exam schedules and allows courses to run with fewer than the institutional standard minimum.

- **Brigham Young University's** support for teacher education is expressed in its founding vision, which states that students should not only learn for themselves but "distribute what they have learned" to help others. Concrete support for physics teacher education appears in the form of support for teacher professional development, outreach activities, and the redesign of classrooms that benefit future physics teachers.

- At **Cal Poly San Luis Obispo**, a center associated with the College of Science and Mathematics (CESAME, the Center for Engineering, Science, and Mathematics Education) has STEM teacher education as a primary responsibility. The dean of the College of Science and Mathematics has shown strong and sustained support for STEM teacher education over many years, not only by sustaining CESAME and the programs that it runs, but also by hiring disciplinary faculty with a primary interest in STEM education over multiple hiring cycles.

- **Georgia State University** is one of 14 institutions in the state university system that states "increased STEM teacher production" as a central goal; thus, the ten-year plan for the institution includes both increasing the number of STEM majors and improving the preparation of high school teachers.

- **Rowan University** was originally founded as Glassboro Normal School (a teacher education institution); the teacher education program at Rowan University is still the largest in the region and the only one that offers single-subject certifications. STEM teacher education is an explicit part of the strategic plan for the College of Science & Mathematics. The STEAM Department (formerly the Teacher Education Department) has STEM teacher education as a high priority. The provost has committed to supporting the Learning Assistant (LA) program after PhysTEC funding comes to an end.

- At **Stony Brook University**, the physics teacher education program is housed in the Institute for STEM Education (I-STEM), a well-funded institute that has overseen the education of science teachers for more than 25 years. I-STEM is comprised of faculty with joint appointments in disciplinary departments who are supported and rewarded for their physics teacher education activities.

Component 1B: Reward Structure

- At **UTeach Austin**, higher administration recognizes that co-directing the UTeach program requires significant time and provides incentives to support the additional responsibility in terms of additional compensation and travel support.

- At **CU Boulder**, two Master Teacher positions are funded, partially by the institution and partially through an endowment. These Master Teachers provide significant support for the program's activities, including course instruction, partnering with local school districts, managing and observing field experiences, and mentoring teacher candidates.

- The faculty leader at **Brigham Young University** has significant time to dedicate to physics teacher education as his regular faculty activity (not in addition to it). He was promoted to full professor for his work in physics teacher education in spite of having a nontraditional background that includes expertise in secondary teaching in the physical sciences. The College of Physical and Mathematical Sciences recently honored him with a prestigious teaching award for his physics teacher education activities.

- At **Cal Poly San Luis Obispo**, one physics faculty member was hired with "physics teacher education" in his job description, and his physics teacher education activities are considered part of his normal required duties in physics. The grants he obtains for physics teacher education projects are publicly celebrated by the university. Across the Cal Poly San Luis Obispo campus, STEM teacher education programs are run by disciplinary faculty with strong STEM education identities who have been hired and promoted partly on the basis of their STEM teacher education activities.

Component 1C: Resources

- At **UTeach Austin**, both the Colleges of Natural Sciences and Education provide significant staff support and other resources for the program, including the program leader's salary, funding for Master Teachers, and education faculty time to teach UTeach courses. Along with endowments, these provide substantial resources for the program to draw upon. Thus, the program can access three tiers of human resources—directors, Master Teachers, and staff—enabling effective high-level leadership (directors), on-the-ground work with future and current teachers (Master Teachers and clinical faculty), and daily operations (staff).

- **Brigham Young University** supports physics teacher education through financial support for teacher professional development and outreach activities and the redesign of classrooms that benefit future physics teachers. There is a tenure-track position in the Physics Department allocated to teacher education.

- At **Cal Poly San Luis Obispo**, STEM teacher education is supported by resources that include substantial, stable institutional funding (for the personnel that run the programs), significant external funding, dedicated space in a central location, and staff that support day-to-day operation. Even though physics teacher education is a small fraction of STEM teacher preparation at this university, the STEM teacher preparation programs are well resourced and stable enough to provide a strong infrastructure.

- At **Rutgers University**, the longevity of the program is a great asset, adding visibility and a strong reputation that draw students to the program, and this creates a strong cohort of local teachers to serve as cooperating teachers during student teaching. In addition, the education college supports specialized science teacher preparation programs, with one faculty member focused on physical sciences and another on life sciences.

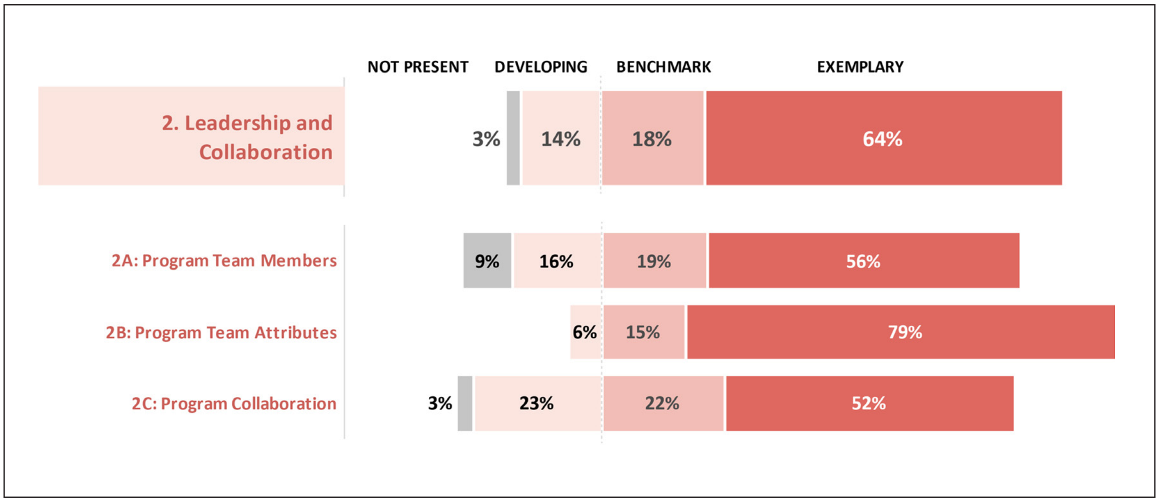
Resources for Improving Institutional Commitment

1. The case studies and findings in the **PhysTEC Sustainability Study** (Scherr, Plisch, and Goertzen, 2014 and 2017) address institutional commitment in detail.
2. The **case studies** in *Recruiting and Educating Future Physics Teachers* (Sandifer and Brewe, 2015) describe how various institutions have supported and rewarded teacher preparation; Vokos and Hodapp (2015) within this resource also directly discuss funding and institutional support.
3. Consistently **communicating** program successes to stakeholders is an element of the PTEPA Rubric in **Standard 6: Program Assessment**, and you will find suggestions on how to accomplish such communication later in this chapter.

Standard 2: Leadership and Collaboration

One of the most critical features of thriving physics teacher education programs is the presence of an effective leadership team. A powerful team includes both people in **positions that enable effective leadership whose expertise, identity, and activities strengthen the program (2A and 2B)** and **effective collaboration between physics and education (2C).** Figure 8 shows the performance of studied programs on this standard and its components.

Figure 8: Performance of studied programs on Standard 2.



The percentage of items within Standard 2 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 2A: Program Team Members *and* Component 2B: Program Team Attributes

- **UTeach Austin** has a robust leadership team consisting of two directors and two co-directors, plus seven Master Teachers; almost half of the team has physics disciplinary expertise, and several have K–12 teaching experience. The leadership team includes two faculty with significant positional power as university-level administrators and one faculty member in the School of Education. The leadership team is supported by a steering committee, which helps it to make programmatic decisions. The seasoned crew of long-term Master Teachers is deeply integrated into the program; they recruit students, teach the courses, run field experiences, advise students, and run the new teacher mentoring program. UTeach leadership sees continuity in the Master Teachers as critical to effective program leadership and student mentoring and has sustained their funding for many years.
- At **CU Boulder**, physics teacher education is led by a tenured faculty member with extensive expertise in physics education and physics education research, engagement in national physics teacher education networks, and a national reputation for leadership in STEM educational improvements. She is supported by two Master Teachers with teaching experience in physics who are deeply integrated across the program, serving as teachers and mentors for future teachers.
- At **Brigham Young University**, physics teacher education is led by a single tenured faculty member in partnership with one Teacher in Residence (TIR). The faculty leader has 19 years of high school physics teaching experience. He is regularly engaged with local school districts; for example, a new Teacher in Residence is loaned to the physics teacher education program each year by a local school district in exchange for a recent physics teacher graduate who takes that teacher's place for the year.

- At **Cal Poly San Luis Obispo**, STEM teacher education programs are run by disciplinary faculty with strong STEM education identities, and physics is heavily represented among these education-oriented STEM faculty. Members of the physics teacher education leadership team include multiple tenured faculty in physics (including the director and co-director of CESAME, the Center for Engineering, Science, and Mathematics Education) and a long-term physics Teacher in Residence. The Teacher in Residence is the placement coordinator, postbac course instructor, and mentor to students.

- At **Georgia State University**, the program leader has positional power (as a tenured professor and associate chair) and broad knowledge of physics education and education research, and he is supported by a co-leader in the School of Education. His team includes other faculty in physics and education (two of whom have expertise specifically in physics education) who support the program's daily operations and enable a smooth path to certification for future physics teachers. A part-time Teacher in Residence provides critical connection to K–12 physics teaching expertise by mentoring students in the Methods course and during student teaching. As at many other programs, the faculty leader is often touted as having the passion, dedication, and caring for students to make the program work.

- At **Rowan University**, the physics teacher education team has included the dean of the College of Science & Mathematics, the Physics Department chair, two other faculty in physics, and two TIRs. Multiple team members have decades of high school teaching experience, and one of the team members is a physics education researcher who also has a joint appointment in physics and education.

- At **Stony Brook University**, members of the physics teacher education leadership team include multiple tenured faculty in physics (one of whom is also a certified physics teacher), the director of the institute that oversees science teacher education (also a certified physics teacher), and multiple Teachers in Residence who intersect with teacher candidates in many settings (including a graduate-level physics pedagogy course and student teacher placement). Members of the faculty team have positional power (such as the institute director), disciplinary expertise in physics, knowledge of and participation in physics education research, and engagement with local schools.

Component 2C: Program Collaboration

- **UTeach Austin** benefits from its status as a separate academic unit, with the co-directors reporting directly to the deans of Education and Natural Science. This enables the program to negotiate agreements at the college level regarding curriculum, faculty appointments, and programmatic decisions. The leadership is able to strategically and consistently communicate to their deans rather than filtering such messages through department chairs. This cross-college partnership is celebrated and made visible by the program and administrators.

- At **CU Boulder**, the faculty leader of physics teacher education is an education faculty member who is a frequent boundary crosser between STEM and Education (by serving on dissertation committees and attending group meetings and events), providing a rich connection to disciplinary context and content. The two CU Teach Master Teachers also collaborate with individuals in different offices and departments regarding student advising and student teaching placement.

- At **Brigham Young University**, the School of Education coordinates with the Physics Department (among numerous other departments) to provide a "secondary education major" incorporating both a disciplinary major and a professional education program leading to eligibility for teacher licensure.

- At **Cal Poly San Luis Obispo**, STEM teacher education programs are run by disciplinary faculty with strong STEM education identities. These boundary crossers are the basis for effective collaboration between STEM teacher education programs and the disciplinary departments, connecting the different science disciplines to each other and to the other bodies that administer teacher education. (In Cal Poly San Luis Obispo's case, the School of Education is a small graduate-only academic unit within the College of Science and Mathematics.)

- At **Georgia State University**, the physics teacher education leadership team includes faculty in physics and education, with multiple professional intersections among them (such as joint committee appointments, membership in dissertation committees, and research collaborations) and a friendly collaborative climate. There are also significant collaborations about physics teacher education program elements, and a variety of formal and informal negotiations have guided the coordination of advising and mentoring, coursework, and student teacher placement across the departments. These agreements are supported by an unusual structure: The Professional Education Faculty is a group that guides collaboration between the School of Education and all other disciplinary units with a stake in teacher preparation (including the Physics Department).

- At **Rowan University**, the physics teacher education program team includes faculty in both physics and education. One of the faculty leaders has a joint appointment in physics and education.
- At **Rutgers University**, the physics teacher education program is housed within the Graduate School of Education and collaborates with the Office of Teacher Education for certification and licensing requirements, field placements, and tracking. The physics teacher education program also collaborates with the Physics Department to provide early teaching experiences to physics teacher candidates, who serve as Teaching Assistants in a reformed introductory course in physics. The program leader collaborates with physics faculty to reform and study courses in the Physics Department, laying a strong groundwork for effective intersections with the department.
- At **Stony Brook University**, the physics teacher education program is housed in the Institute for STEM Education (I-STEM), a well-funded institute that has overseen the education of science teachers for more than 25 years. I-STEM is comprised of faculty with joint appointments in disciplinary departments, who are supported and rewarded for their physics teacher education activities. These boundary crossers are the basis for effective collaboration between I-STEM and the disciplinary departments.

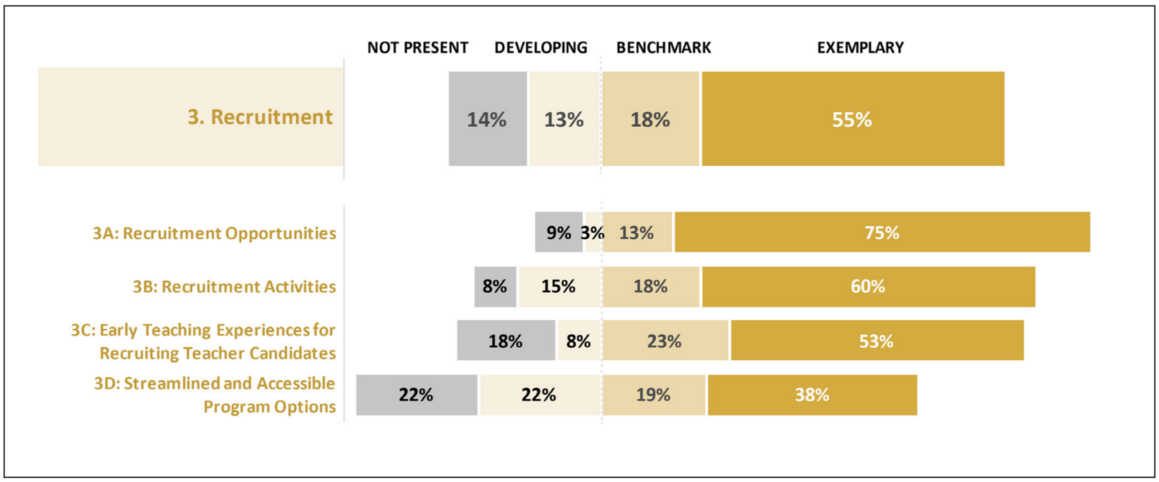
Resources for Improving Leadership and Collaboration

1. Descriptions of different **program leadership and team structures** can be found in Scherr, Plisch, and Goertzen (2014 and 2017) and Sandifer and Brewe (2015).
2. Many ideas on how to recruit and use **Teachers in Residence** can be found in Plisch, Blickenstaff, and Anderson (2015), within *Recruiting and Educating Future Physics Teachers.*
3. Discussion of **collaboration** opportunities between academic units is discussed in Meltzer, Plisch, and Vokos (2012) and Vokos and Hodapp (2015).
4. The **Accelerating Systemic Change Network**[1] has many resources and webinars aimed at helping “change leaders” to develop their leadership skills.

Standard 3: Recruitment

A thriving physics teacher education program necessarily brings many teacher candidates into the program. Some do so by taking advantage of **local recruitment opportunities (3A)**, or **they may actively promote the program (3B)** to draw in students through promotional activities, proactive advising, and the presence of positive ambassadors for the teaching profession. **Early teaching experiences (3C)** are often used to give first- or second-year students a taste of the rewards and challenges of teaching, and **streamlined and accessible options for degree and licensure (3D)** are of key importance in convincing students to commit to a physics teaching career. Figure 9 shows the performance of studied programs on this standard and its components.

Figure 9: Performance of studied programs on Standard 3.



The percentage of items within Standard 3 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 3A: Recruitment Opportunities

- At **CU Boulder**, a large number of physics majors (57/year) and physics-like majors (e.g., astrophysics, engineering physics, mechanical engineering, and electrical engineering) provide a significant pool from which future physics teachers can be recruited. The teacher education program (CU Teach) has been in existence since 2006 and has established a strong local reputation; local districts are eager for CU Teach graduates. Its longevity has resulted in the placement of many graduates in the local area, creating a local network for program recruitment. CU Teach also has a clear identity, with clear branding, a logo, a website, and marketing materials (such as mugs and T-shirts).
- **Brigham Young University** has a large number of physics majors (about 45/year), which they attribute to the caring and supportive atmosphere of the Physics Department.
- At **Rowan University**, there is a large number of physics majors (over 150 and growing) and an even larger population of physics-aligned majors (in engineering and chemistry). Many physics teacher graduates teach in the region, sometimes recruiting their students to the teaching profession.
- At **Rutgers University**, the longevity of the program has been a great asset, creating visibility and a strong reputation that draw students to the program, and this has resulted in a strong cohort of local teachers who refer their students to the program.

Component 3B: Recruitment Activities

- **UTeach Austin** uses a plethora of recruitment strategies: Announcements are made at summer orientation and in large STEM introductory and service courses, and postcards and letters are sent to incoming and continuing students at the university to inform them about the program.
- **CU Boulder's** associated program, CU Teach, hosts informational tables during registration each semester and during CU Welcome days at the start of the year. The Master Teachers visit introductory STEM classes to bring visibility to the program. CU Teach is mentioned during the LA pedagogy course, and letters about CU Teach are sent to all first-year students.
- At **Brigham Young University**, the faculty leader of the physics teacher education program is a positive ambassador for the teaching profession, having been a high school physics teacher himself for 19 years.
- At **Georgia State University**, the physics teacher education program leader is also the student advisor and thus has ready access to discuss career options with students, including teaching. His role also gives him visibility among other faculty as the "go to" person for teaching careers.
- At **Rowan University**, multiple physics faculty mentors are strong supporters of physics teaching.
- At **Rutgers University**, the physics teacher education program leader announces the program each year in the SPS chapter meetings, and the undergraduate program director proactively refers interested students to the teacher education program. Additional visibility for the program is generated through a physics course taught for in-service physics teachers by a program graduate.

Component 3C: Early Teaching Experiences for Recruiting Teacher Candidates

Note that early teaching experiences are those that are intended primarily to give an early experience with teaching rather than experiences intended to develop the teaching practice; such field experiences (including student teaching) are addressed in Standard 4. Early teaching experiences may include sustained tutoring, sustained outreach, LA experiences, and STEP or other entry-level courses, among other possibilities.

- At **CU Boulder**, physics teacher candidates are recruited from two particularly popular early teaching experiences: STEP 1 (a one-credit CU Teach course in which students teach lessons in elementary school) and the LA program (in which undergraduates work with faculty members to ensure collaborative opportunities for students in a paid position accompanied by a pedagogy course). The flagship institution for the LA program, CU Boulder supports a large number of LAs (over 20 in physics each term), provides well-established structures for mentoring these LAs, and exposes students to the scholarship and expertise of teaching with a well-developed pedagogy course.
- **Cal Poly San Luis Obispo** offers a variety of high-quality, popular, well-funded early teaching opportunities that recruit students into science teaching and develop their pedagogical skills. These programs include the Learn By Doing Lab (LBDL), in which undergraduates are mentored to design science lessons for 5th–8th grade students who come to campus; Teacher Assistants in Math and Science (TEAMS), in which undergraduates assist in 7th–12th grade classrooms; and Mentors in Out-of-School Time (MOST), in which undergraduates teach STEM-focused modules in an after-school program at a local school. Many undergraduates participate in these experiential learning programs whether or not they intend to pursue a career in teaching. Thus, the programs are campus-wide opportunities for recruitment.
- At **Rowan University**, convenient, attractive early teaching experiences include a large LA program in which participants are informed about the physics teacher education program and are encouraged, as a group, to consider physics teaching as a career. Teacher candidates in the LA program are placed in physics classes at Glassboro High School, conveniently located across the street.

Component 3D: Streamlined and Accessible Program Options

- At **UTeach Austin**, program leadership is very concerned about issues of equity and inclusion among teacher candidates. If a career in teaching will require extra time (and tuition), then students from traditionally under-served populations are less likely to be able to pursue certification. Thus, the program is explicitly designed as a four-year undergraduate program (or a three-semester post-baccalaureate program). Students can receive certification even without enrolling in the teaching option within their major; they can receive a traditional undergraduate degree with certification as an "add-on" to that major. This efficiency is accomplished by streamlining the pedagogical preparation sequence and using UTeach courses to satisfy multiple requirements. The program is also made more accessible with significant financial support through internships, Noyce fellowships, and several internal UTeach scholarships.

- **Brigham Young University** offers an attractive physics teaching major through which undergraduates can get both a disciplinary major and teacher licensure in 4–5 years.

- At **Georgia State University**, physics majors can elect an education concentration within their degree and can complete requirements for the degree plus licensure in 4–5 years. The existence of several concentrations with the physics B.S. degree made it relatively straightforward to create this education concentration; additionally, the hours required for certification (21 hours) conveniently matched the number of elective hours available within the physics concentration.

- At **Rowan University**, the explicit mission of the Physics Department supports three career tracks with equal weight—physics graduate school, physics teaching, and industry—each supported by degree options and advising structures. Multiple physics faculty mentors are strong supporters of physics teaching.

- The **Rutgers University** Physics Department provides an undergraduate B.A. degree with fewer credit requirements, enabling physics students to complete a teaching certification in a manageable amount of time.

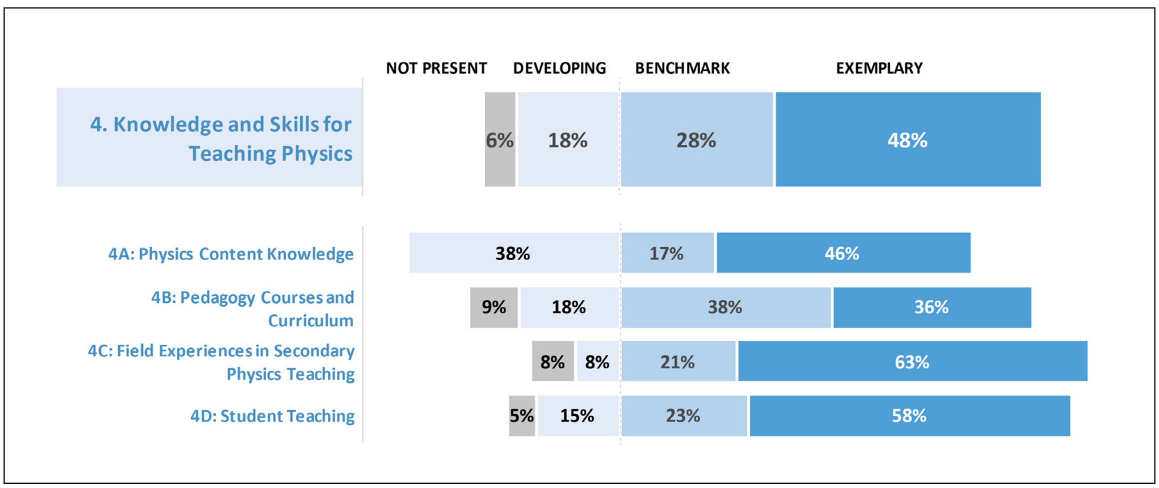
Resources for Measuring and Improving Recruitment

1. The **case studies** in *Recruiting and Educating Future Physics Teachers* (Sandifer and Brewe, 2015) describe how various programs have addressed recruitment; Vokos and Hodapp (2015) within this resource provide a useful overview of recruiting approaches and early teaching experiences.
2. For more information about **early teaching experiences** in particular, see the section "Structuring Effective Early Teaching Experiences" in Sandifer and Brewe (2015), the Learning Assistant Alliance,[2] and the PhysTEC website.[3]
3. To improve your recruitment approaches, consider creating a **strategic recruitment plan** and rigorous selection criteria as discussed in the Council for the Accreditation of Educator Preparation (CAEP) standards (Council for the Accreditation of Educator Preparation, 2016,[4] pp. 37–38).
4. For measurement of the **climate toward teaching in the physics department**, consider the Perceptions of Teaching as a Profession (PTaP)[5] survey and the Survey of Climate for Instructional Improvement (SCII).[6]
5. For a general discussion of **secondary science certification routes**, see the Secondary Content in the Sciences[7] standard from the National Council on Teacher Quality (NCTQ).

Standard 4: Knowledge and Skills for Teaching Physics

The very purpose of a physics teacher education program is to provide teacher candidates with the knowledge and skills they need for effective physics teaching. The thriving program case studies demonstrate great variety in this standard, likely due to the diversity of structures and collaborations between education and physics and the challenge of providing substantive physics teacher education to a small number of students. **Strong physics content knowledge (4A)** is a key area, usually addressed by requiring physics teacher candidates to have a physics major or minor. Another key area is excellent **coursework in physics pedagogy (the study of physics teaching and learning) (4B)**, which may appear in the form of standalone courses or as part of science methods courses. Some programs are able to offer **field experiences in secondary physics teaching (4C)**, in which teacher candidates put education coursework into practice in a school setting by teaching (or helping to teach) a pre-college class. Eventually, all teacher candidates have a **student teaching experience (4D)**, in which they have full control of multiple classes for at least a semester. Figure 10 shows the performance of studied programs on this standard and its components.

Figure 10: Performance of studied programs on Standard 4.



The percentage of items within Standard 4 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 4A: Physics Content Knowledge

Additional examples of programs offering strong physics content knowledge preparation can be found in the *Phys21* report (Heron and McNeil, 2016).

- **CU Boulder** has a long history of research-based teaching in introductory physics, which provides a strong foundation of physics content knowledge for future teachers.
- At **Georgia State University**, an education concentration within the physics B.S. degree ensures deep physics content knowledge among graduates. This strong foundation in content is bolstered by the increasing use of research-based instructional practices in the introductory course and a research requirement in the physics degree.
- **Stony Brook University** has a reputation for a highly rigorous physics major; physics teachers graduating from there are assumed to have very strong content knowledge.

Component 4B: Pedagogy Courses and Curriculum

- **UTeach Austin** provides preparation to teach a variety of STEM content through a sequence of STEM-general pedagogy courses, which was motivated by state certifications that require teacher candidates to be able to teach a variety of subjects. The strong physics background of many of the faculty and instructors in the program enables them to provide a substantial physics component in these general courses, and physics students often work in a cohort within those courses to apply the lessons to physics. These courses replace some of the typical generic courses often offered through the school of education (such as classroom management and educational psychology) so that the course sequence is directly relevant and motivating to STEM students. UTeach Austin also offers a Physics by Inquiry course, taken by many future physics teachers, which provides high-quality pedagogical and content preparation.

- At **CU Boulder**, students gain physics-specific pedagogy through a Teaching and Learning Physics course (in the Physics Department) that fulfills the CU Teach program requirement to take at least two disciplinary "teaching and learning" courses. Additionally, the Energy and Interactions course (a guided inquiry course for non-majors) strengthens students' training in scientific practices.

- At **Brigham Young University**, coursework for the physics teaching major includes multiple guided inquiry physics courses taught by the faculty leader; the courses use the well-regarded Physics by Inquiry instructional materials. These courses, focused entirely on physics-specific pedagogy, embody and promote evidence-based physics teaching practices and occupy more than six credits of the physics teaching major curriculum.

- At **Rutgers University**, students receive a total of 18 credits of instruction across six courses focused on physics content and pedagogy. The separate preparation of physics and biology teachers at the institution (as well as the leadership by faculty in the Graduate School of Education) enables this heavily discipline-focused curriculum. The coursework builds strategically across topics, and the focus is well aligned with experiential learning opportunities. Students learn how to teach a core set of topics in their first-year science methods courses and then apply those techniques as mentored teaching assistants in a transformed

Future teachers investigate physics through hands-on inquiry. RICHARD E. SCHULTZ introductory physics course. Students also engage in frequent "microteaching" within the physics methods courses, where they prepare and present short lessons to their peers and receive critical feedback.

Component 4C: Field Experiences in Secondary Physics Teaching

Note that field experiences are in-classroom K–12 teaching experiences for teacher candidates, preferably in a physics or physical-science classroom with an on-campus course component. The goal of a field experience is for candidates to put education coursework into practice by teaching (or helping to teach) a pre-college class. Field experiences are supervised by a "cooperating teacher," who is a certified teacher at the school.

- At **UTeach Austin**, students first recruited into the program engage in two one-credit seminars (STEP1 and STEP2) in which they prepare and present short lessons to elementary and middle school students. In the (multiple) pedagogy courses, students teach short lessons in local schools as a field experience, and apprentice teaching offers further in-school experience. There is also an optional internship program, where students are paid a stipend to work in the field with local educational organizations.

- At **CU Boulder**, students accumulate almost 150 hours of classroom experience before their student teaching experience—a relatively large number by national standards. This field experience is accumulated through the STEP courses (in which students engage in elementary and middle school classrooms) and school-based practicum in several of the core courses (Knowing and Learning in Mathematics and Science, Classroom Interactions, Problem-Based Science Instruction, and Differentiating Instruction in Diverse Secondary Classrooms). These field experiences require a significant network of local teachers along with staff time for observations of students in the classroom, all of which is supported by the team of Master Teachers.

- At **Georgia State University**, students complete 16–20 hours per week of "practicum" in a high school classroom in the semester prior to student teaching. Candidates also visit a middle school physical science classroom for two weeks to gain experience with diverse grade levels. The program has worked hard to develop a set of good cooperating teachers for placements and now has a sufficient number, the vast majority of whom use best teaching practices.

- At **Stony Brook University**, the physics teacher education program includes a state-required 100 hours of observation in schools; this observation usually includes active participation as an assistant teacher. These field experiences are hosted by highly qualified physics teachers in the area, many of whom are program graduates.

Component 4D: Student Teaching

Note that student teaching is a capstone field experience in which a teacher candidate teaches in a pre-college setting with full control of multiple classes for at least a semester, fulfilling licensure requirements. The student teaching experience is jointly supervised by the "cooperating teacher," who is a certified teacher at the school where the field experience takes place, and the "university supervisor," who is a member of the university faculty with expertise in teacher education.

- **UTeach Austin** has access to many high-quality mentor teachers for student teaching and field experiences due to the longevity of its program, the large number of local graduates, and the work of program staff to cultivate strong local K–12 relationships. Two Master Teachers coordinate the student teaching experience, meet with teacher mentors, and individually place students. Most students wishing to teach physics are placed with a physics teacher; however, since their state does not have single-field licensure, physics majors may be called on to teach other disciplines.

- At **Georgia State University**, the university supervisor is the Teacher in Residence, providing a direct connection to physics teaching expertise. This connection is critical given that the science methods course is science-broad and is taught by faculty without physics-specific expertise.

- At **Rutgers University**, the longevity of the program has created a high concentration of highly qualified teachers in the area who use the inquiry-based methods taught in the program. Students are individually placed with these teachers based on their needs, with the program leader collaborating closely with the Office of Teacher Education to direct this placement. The program leader creates informal agreements with cooperating teachers about how those cooperating teachers will mentor the pre-service teachers in their classrooms, provides individual oversight for those student teaching experiences, observes every student teacher during the student teaching experience, and uses those observations to drive classwork in the course that accompanies student teaching.

Resources for Measuring and Improving Knowledge and Skills for Teaching Physics

1. The **case studies** in Sandifer and Brewe (2015) include a "Preparation in the Knowledge and Practices of Physics and Physics Teaching" section.

2. ***Teacher Education in Physics: Research, Curriculum, and Practice*** (Meltzer and Shaffer, 2011) includes a rich set of papers regarding the design of courses and experiences to support physics teachers' pedagogical knowledge.

3. **PhysPort**[8] includes many physics-specific assessments of content knowledge.

4. **The *Phys21* report** (Heron and McNeil, 2016) includes a suggested list of learning goals for physics programs.

5. Measurement of the **teaching approaches** used in the introductory course can be achieved through a variety of available surveys on instructional practice; see Williams, Walter, Henderson, and Beach (2015).

6. Recommendations for **research-based course design**, including assessing student outcomes, can be found in National Research Council (2015), "Reaching Students."

7. **The Teacher Preparation Analytics' "Key Effectiveness Indicators"** provides a useful list of metrics—such as scores on licensure exams, GPA, and GRE scores—that can be used to assess content matter and pedagogical mastery.

8. The *CAEP Accreditation Handbook*[9] from **the Council for the Accreditation of Educator Preparation** lists possible measures that can be used to assess content and pedagogical knowledge and clinical partnerships and practice (CAEP Standards 1 and 2), such as unit lesson plans, capstone assessments, written agreements with cooperating teachers, and observational instruments.

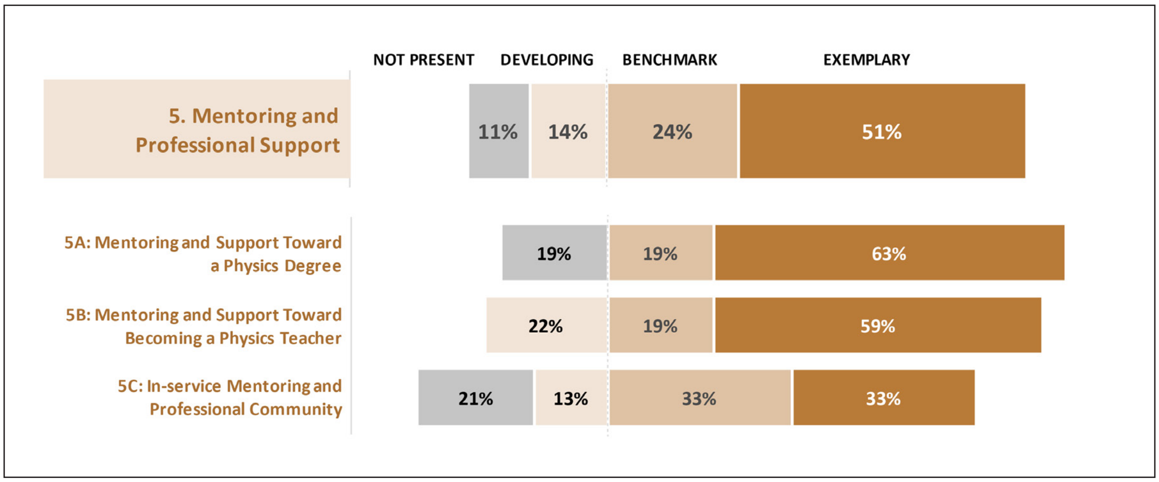
9. Descriptions of **course structures** for physics pedagogy courses and strategies for achieving course minimum enrollments are in Vokos and Hodapp (2015); Meltzer, Plisch, and Vokos (2012); and Etkina (2010).

10. Suggested approaches to **subject matter and pedagogical preparation, field experiences, and student teaching**, including metrics for success and ideas for improvement, are available from The National Council on Teacher Quality (NCTQ); see Secondary Content in the Sciences,[10] Secondary Methods,[11] and Student Teaching[12] standards.

Standard 5: Mentoring and Professional Support

A thriving physics teacher education program provides **mentoring to support progress toward a physics degree (5A)** and specifically **toward becoming a physics teacher (5B)**, ideally in the form of personalized mentoring from a faculty advisor who is well informed about physics teacher education and physics teaching itself. Many thriving programs also support **retention in the physics teaching profession (5C)** with mentoring and professional development for local in-service physics teachers. Figure 11 shows the performance of studied programs on this standard and its components.

Figure 11: Performance of studied programs on Standard 5.



The percentage of items within Standard 5 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 5A: Mentoring and Support Toward a Physics Degree *and* Component 5B: Mentoring and Support Toward Becoming a Physics Teacher

Additional case studies of institutions employing strong advising and mentoring within their physics degree program can be found in *Phys21* (Heron and McNeil, 2016).

- **UTeach Austin** employs seven Master Teachers whose roles include advising and mentoring students. There are also two dedicated advisors in addition to the Master Teachers. Advising is required; students cannot register for courses until they speak to their UTeach advisor. Student community is also supported in many ways, such as through social events (with free food), a UTeach student lounge, and a student association.
- At **CU Boulder,** the two CU Teach Master Teachers provide a high level of support and mentorship. Because the Master Teachers are deeply integrated in the program, teaching multiple courses and observing students in the classroom, they know students personally, become familiar with their strengths and challenges, and interact with them throughout their academic careers. The Master Teachers also interact with the staff advisor to ensure students are on track. Students are part of a strong community, with small classes and substantial group work and team teaching. The program

hosts frequent social events, such as potlucks and an annual tie-dye night (where CU Teach T-shirts are tie-dyed, also providing greater visibility for the program).

- At **Brigham Young University**, the program leader closely advises and mentors teacher candidates. His charisma, K–12 experience, and pedagogical content knowledge are major strengths of the program.

- At **Georgia State University**, the faculty leader is also the undergraduate student advisor in physics and provides personalized advising and mentorship to all physics students. He is knowledgeable about the requirements in physics (for the education concentration) as well as the certification requirements (in education), and so he is able to advise students on their career paths and provide a roadmap of courses while also helping them navigate the hurdles and idiosyncrasies of licensure. A program coordinator in education provides specific guidance in that department (e.g., on completing requirements and registration).

- At **Rutgers University**, the program leader is the advisor for all physics teacher candidates (or a co-advisor with the physics advisor for those in the undergraduate program). As a former high school teacher and the instructor in students' core courses, this faculty leader knows students personally and is able to advise them individually. Her "tough love" approach with students enables them to rise to the challenges of teaching as a profession. Students develop a strong sense of community in the program as they collaborate intensively on coursework, lesson planning, microteaching, and field experiences.

Component 5C: In-service Mentoring and Professional Community

- **UTeach Austin's** substantial cadre of Master Teachers enables it to offer services that not every program can manage, including an in-service teacher support program. New teachers enrolled in this optional program meet with one of the Master Teachers during their first year of teaching. All new teachers receive a care package with useful supplies, such as markers and Post-it notes. There is also an active alumni association, and UTeach offers many professional development opportunities for those alumni, including an alumni conference every summer, teacher training workshops, online development, and invitations to campus to speak to current students.

- At **Rowan University**, one of the Teachers in Residence runs a professional group for local physics teachers (Rowan Area Physics Teachers; RAPT). The teacher group meets four to five times a year, and undergraduate LAs attend the group meetings to network with the teachers.

- At **Rutgers University**, program graduates are highly committed to one another and the alumni community. The faculty leader offers program alumni monthly "Friday meetings," which are consistently attended by many graduates. In these meetings and in an active Facebook group, teachers share ideas and get help addressing challenges in their teaching. This strong community ensures that teachers get support in teaching using inquiry methods and helps them to persist in their careers. Many pre-service teachers attend these meetings starting in their second year in the program.

Resources for Improving Mentoring and Professional Support

1. Descriptions of **advising and mentoring** structures are in several articles (Vokos and Hodapp; Nordine et al.) within *Recruiting and Educating Future Physics Teachers* (Sandifer and Brewe, 2015), as well as in the T-TEP report (Meltzer et al., 2012).

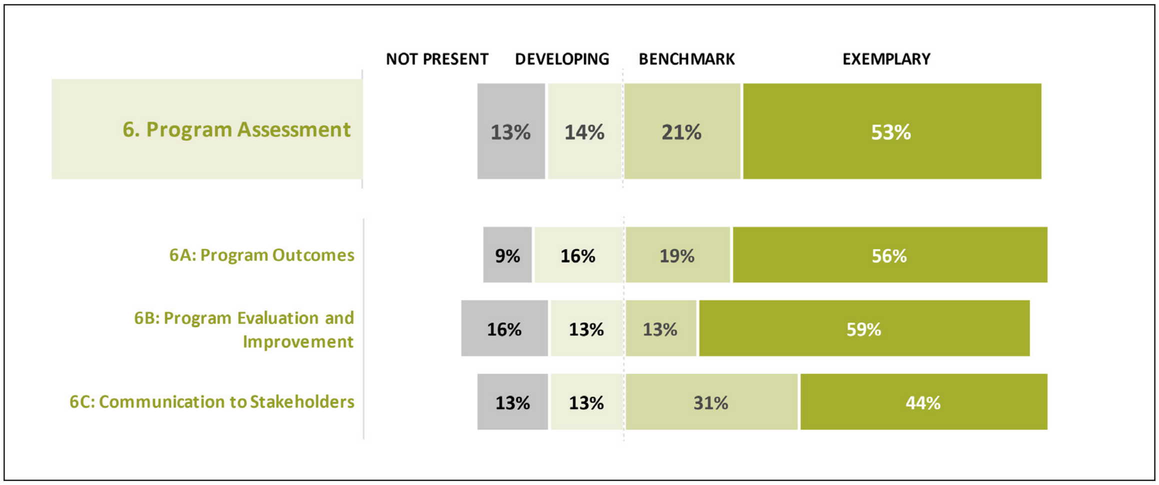
2. ***Phys21*** (Heron and McNeil, 2016) and the ***SPIN-UP*** report (Hilborn, Krane, and Howes, 2003) contain recommendations on advising of physics majors.

3. **The APS "Physics Research Mentor Training Seminar"**[13] provides useful guidance for mentor training.

Standard 6: Program Assessment

A thriving physics teacher education program engages in robust self-assessment. This includes **measuring multiple outcomes (6A)** and systematically collecting and analyzing student and program-level data to make informed decisions about **program development and improvement (6B)**. In addition, a thriving program **communicates its success to key stakeholders (6C)** to build support for the program. Figure 12 shows the performance of studied programs on this standard and its components.

Figure 12: Performance of studied programs on Standard 6.



The percentage of items within Standard 6 and each of its components achieving Exemplary, Benchmark, Developing, or Not Present status across the eight studied programs. For performance across all items in the standard, see Appendix A6.

Component 6A: Program Outcomes

A thriving physics teacher education program is successful at recruiting and graduating teacher candidates. All of the programs studied so far have annual graduation rates that regularly exceed five teachers per year.

Component 6B: Program Evaluation and Improvement

- At **UTeach Austin**, one of the program directors is an enthusiastic number-cruncher; he looks at program data carefully and consistently. He produces reports that all program instructors and staff study at the beginning of each semester. Some of these reports provide simple descriptive statistics, such as the numbers of students in every course. Other reports, such as retention reports on all graduates, are more challenging to generate, as they require tracking the location of all graduates and determining if they are still teaching. The teaching status of more than 95% of all graduates of UTeach Austin is known.
- **Georgia State University's** physics teacher education program metrics are tracked through the School of Education, creating a database of information on recruitment, placement, and retention. In addition, because the program leader is also the undergraduate advisor in physics, he keeps student data to effectively advise students as they complete their degree. This program data is valuable for informing program

improvements as well as communicating to administrators about program successes.

- At **Rutgers University**, the program is housed within the Graduate School of Education, allowing the program leader to leverage the data tracking that already occurs within the unit. Rich, informal assessments also guide continual improvements in the program and curriculum; the program leader has close relationships with students (as advisor and course instructor), alumni (through regular alumni meetings and informal classroom observations), and employers (through connections to local school districts).

Component 6C: Communication to Stakeholders

- At **UTeach Austin**, the program leaders and collaborating administrators are unusually active as advocates for state-level policy changes that could benefit the program; their activities include testifying before the state legislature and before the State Board for Educator Certification, which is responsible for state standards and certification requirements. These activities have brought visibility to the program and have helped to streamline licensure requirements to help minimize the time to degree.

- At **Georgia State University**, college deans are aware of the success of the physics teacher education program; the program leader is in regular contact with college-level administrators, sharing results and successes (including the program's membership in the 5+ Club). He meets in person with administrators in education (including the chair of Middle and Secondary Education and the dean of Education), interactions that are enabled by the small size of the College of Education. For the larger College of Arts and Sciences, he sends emails to the dean and interacts directly with the associate deans and the chair of the Physics Department to share news of the program. This communication helps to create an overall favorable climate for continued program support.

A future physics teacher leads an aerodynamics lesson with middle school students while a Master Teacher looks on. TWAY PHOTOGRAPHY

Resources for Improving Program Assessment

1. **The Teacher Preparation Analytics' "Key Effectiveness Indicators**" provides a useful list of metrics for assessing teaching skills, impact on K–12 learning, employment and persistence, and alumni feedback.

2. ***Assessing and Evaluating Teacher Preparation Programs*** (Worrell et al., 2014[14]) provides detailed recommendations on strategic assessment of programs, including measuring teacher performance, surveys of program completers and other stakeholders, and measuring K–12 student academic growth.

3. **The Framework for Teaching Evaluation instrument** (Danielson, 2014) provides a detailed rubric for evaluating many aspects of teacher preparation that are not assessed on the PTEPA Rubric, such as knowledge of students, ability to design coherent instruction, classroom management, and ability to reflect on one's own teaching.

4. The **Council for the Accreditation of Educator Preparation** (CAEP) handbook includes several metrics of the quality of assessment practices within a program, such as the use of stakeholders and engagement in continuous improvement practices (Council for the Accreditation of Educator Preparation, 2016,[15] Standards 4 and 5). Such metrics include employer surveys, graduating student interviews, a schedule and process for continuous review, and support for effectiveness of assessment instruments.

5. **PhysTEC's Key Components** page on assessment[16] includes suggested measures of teacher quality and career outcomes and retention.

6. ***From Compliance Reporting to Effective Communication: Assessment and Transparency*** (Jankowski and Cain, 2015) includes many useful suggestions for targeted, purposeful communication of assessment results to stakeholders for a clear purpose.

7. ***Don't Be Such a Scientist: Talking Substance in an Age of Style*** (Olson, 2009) provides practical tips and frameworks for framing your message about data to the audience.

SUMMARY

The thriving programs observed for this study achieved excellence on the PTEPA Rubric components and items in diverse ways. The rubric structure allows systematic categorization of those strategies and structures according to the outcomes that they help to achieve, and it can support other programs in attempting to address their own programmatic gaps.

A future teacher leads an inquiry-based lesson for a university outreach program. TWAY PHOTOGRAPHY

ENDNOTES

1 Accelerating Systemic Change Network at http://ascnhighered.org.

2 Learning Assistant Alliance at http://learningassistantalliance.org.

3 Learning Assistant resources from PhysTEC at https://www.phystec.org/keycomponents/assistants.cfm.

4 CAEP handbook at http://caepnet.org/accreditation/caep-accreditation/caep-accreditation-handbook; see particularly the "Measures or Type of Evidence" sections, which follow the Evidence Tables within each standard.

5 More information about the PTaP at https://www.aps.org/units/fed/newsletters/fall2017/survey.cfm.

6 More information about the SCII at https://wmich.edu/changeresearch/projects/develop-instruments.

7 NCTQ secondary content resources at https://www.nctq.org/review/standards#standard22.

8 PhysPort list of assessments at https://www.physport.org/assessments/.

9 CAEP handbook at http://caepnet.org/accreditation/caep-accreditation/caep-accreditation-handbook; see particularly the "Measures or Type of Evidence" sections, which follow the Evidence Tables within each standard.

10 NCTQ secondary content in the sciences resources at https://www.nctq.org/review/standards#standard22.

11 NCTQ secondary methods resources at https://www.nctq.org/review/standards#standard11.

12 NCTQ student teaching resources at https://www.nctq.org/review/standards#standard6.

13 "Physics Research Mentor Training Seminar" at http://www.aps.org/programs/education/undergrad/faculty/upload/Physics-Research-Mentor-Training-Seminar.pdf.

14 Assessing and Evaluating Teacher Preparation Programs report at http://www.apa.org/ed/schools/teaching-learning/teacher-preparation-programs.pdf.

15 CAEP handbook at http://caepnet.org/accreditation/caep-accreditation/caep-accreditation-handbook; see particularly the "Measures or Type of Evidence" sections, which follow the Evidence Tables within each standard.

16 PhysTEC assessments page: https://www.phystec.org/keycomponents/assessment/.

CHAPTER 5

What Are Some Challenges Observed at Thriving Programs?

Even thriving physics teacher education programs experience challenges associated with the PTEPA Rubric standards.

INTRODUCTION

The previous chapter (Chapter 4: "What Are Some of the Strongest Elements Observed at Thriving Programs?") highlighted some of the many ways in which thriving physics teacher education programs achieve success. However, most programs also experience challenges, and these challenges were evident in the program visits. Some challenges were observed as weaker ratings in areas of the Physics Teacher Education Program Analysis (PTEPA) Rubric; other challenges represented significant hurdles along the path to programmatic success, even when the program was highly rated in that area. The challenges described below represent observations from these program visits and do not necessarily describe what other programs might experience (though many are not uncommon). Other sources also document common challenges for physics teacher education programs (e.g., Meltzer, Plisch, and Vokos, 2012). Possible responses to such challenges are provided below and are based on observations at the thriving programs visited, existing reports and literature, and experience of the authors. Additional resources and reports that are relevant for supporting achievement of the PTEPA Rubric standards can be found in Chapter 4.

CHALLENGES ASSOCIATED WITH STANDARD 1: INSTITUTIONAL COMMITMENT

Turnover in university administration reduces support for physics teacher education (1A)*

A supportive dean or provost can make a strong contribution to physics teacher education by creating faculty lines for personnel who lead physics teacher education and supporting programs that benefit physics teacher education. When such an administrator leaves the role, however, the support provided by that person for personnel and programs can disappear.

Possible response: Such change highlights the need to communicate consistently with university leadership about program successes (6C) to maintain visibility and support for the program as well as to cultivate a

In the following text, a number and letter in parentheses, like "(1A)," indicates the component in the PTEPA Rubric that is being referenced.

Future teachers lead inquiry-based lessons for a university outreach program. TWAY PHOTOGRAPHY

network of administrators with a keen interest in teacher preparation.

Achievements in teacher preparation are obscured among other achievements (1B)

Many successful program leaders are well known for championing other STEM education improvement efforts and may receive significant accolades for those achievements (such as teaching awards or funding for STEM educational improvements). Though powerful and well-recognized faculty leaders are major assets to physics teacher education programs, there are times when their achievements in physics teacher education may be lost among their other, better-recognized accomplishments.

Possible response: Program leaders with other achievements in STEM education can often leverage their reputations to benefit physics teacher education. To support recognition of STEM teacher preparation as a significant and worthwhile effort, programs can advocate for hiring, promotion, release time, and awards based on STEM teacher preparation efforts (1B).

Funding is difficult to sustain (1C)

External funding, such as a PhysTEC award, may be used to start a physics teacher education program and provide initial funding for expenses that are difficult to otherwise support, such as a new Teacher in Residence or Learning Assistant program. However, even thriving physics teacher education programs find that sustaining these activities and structures requires constant, active reinvestment. Program leaders have to engage in continual advocacy, ongoing renewal of resources, and consistent education (and re-education) of administrators, and they must be generally active in sustaining all aspects of the program. Without this ongoing advocacy, vital aspects of the program can fade away. Low numbers of program graduates as well as the long timescale for program achievements (from recruitment to program completion to placement and retention in the profession) make it harder to make a case for continued funding.

Possible response: One way to address this challenge is through robust collaboration with the school of education (or equivalent; 2C), where it may be possible to leverage existing resources such as administrative staff, instructional lines, or collection of recruitment data. Some programs have also built a multidisciplinary program that involves several STEM departments to boost enrollment numbers and to be more attractive to the institution. Consistent assessment of program successes and communication of those successes to higher administrators can help create long-term program support (6A, 6B, 6C). More recommendations for improving institutional commitment are included in Chapter 4.

CHALLENGES ASSOCIATED WITH STANDARD 2: LEADERSHIP AND COLLABORATION

Funding for Teachers in Residence is difficult to sustain (2A)

Many physics teacher education programs find it particularly challenging to fund Teachers in Residence (TIRs) since these positions often do not align with existing departmental budgets. In addition, universities may not fully appreciate the professional expertise offered by experienced K–12 teachers. Complex programs that need multiple TIRs can be expensive to fund in the long term, requiring substantive institutional commitment and/or external funding sources. Funding TIRs can be challenging for program leaders (who seek the funding), for TIRs (who may lack job security at the university), and for school districts (who may need to negotiate leave for skilled teachers).

Possible response: One approach to sustaining the TIR is through an appointment to an existing position, such as instructor or lab manager, and then redefining some of the responsibilities of that position to include TIR activities. Another approach is to share the expense of the TIR position among multiple units, such as the physics department, the College of Arts and Sciences, and/or the school of education. A TIR may also be maintained through deep collaborations between school districts and universities (2B), where TIRs are funded partially by both for a smaller teaching load and increased responsibilities for teacher preparation. Other solutions involve part-time TIRs, who provide connection to K–12 teaching environments and mentor physics teacher candidates even though they cannot be as deeply integrated into a program as a full-time staff member. In the absence of a TIR, the program may recruit other physics-specific mentors for teacher candidates, such as physics faculty with K–12 experience or cooperating teachers for field experiences and student teaching.

Turnover in faculty leadership reduces support for physics teacher education (2A, 2B)

In a physics teacher education program, losing a faculty leader in either physics or education can be a stumbling block. For example, losing a faculty leader in physics may leave the physics department without a champion of physics teacher education. Losing a faculty leader in the school of education can disrupt the (often informal) agreements about who handles paperwork, advising, and student teacher placements.

Possible response: The departure of a faculty leader can be an opportunity to explicitly negotiate the agreements and responsibilities of team members and their partners (2C) and to forge new alliances. Another strategy is for a remaining program leader to join the hiring committee to replace the faculty member who left.

Program elements in physics and education are disconnected (2C)

Most physics teacher education programs have elements in both the physics department and the school of education, with discipline-specific preparation happening in the former and licensure requirements being met in the latter. The school of education is likely to have low visibility in the physics department, and physical distance between the buildings where these units are housed can exacerbate the divide. Upon entering the licensure part of the program, physics students may feel separated from their physics cohort and sense of identity as a physics student. Some report feeling “handed off” to the school of education; some are disoriented by education terminology, new advising structures, and STEM-wide course content (such as safety plans for labs or more biology-oriented instruction in the science teaching methods course). Schools of education sometimes do not place a high value on discipline-specific preparation, which can further alienate physics students.

Possible response: A response to this challenge is for the physics teacher education program to cultivate strong bases in both physics and education, including developing physics faculty with a personal motivation to improve physics teacher education (2B) and boundary crossers who facilitate effective collaboration between physics and education (2C). A key perspective is to first seek to understand the goals and concerns of science education faculty and school of education leaders and then form partnerships that help address these concerns and goals. Specific actions could include applying for joint grants (e.g., Noyce) or building a program that brings recognition to the university as a whole. Teachers in Residence or other physics teaching advisors (2A, 2B) can serve as a supportive bridge between education and physics content and help students navigate the unfamiliar territory.

CHALLENGES ASSOCIATED WITH STANDARD 3: RECRUITMENT

The undergraduate physics program does not provide fertile ground for recruitment (3A)

In some cases, the pool of physics majors is not adequate for recruitment into the teaching profession, either because there is a small number of majors (not observed at any thriving programs in this study) or because it is difficult to recruit these majors into teaching. Weaknesses in undergraduate physics teaching may especially deter students from considering a physics teaching career and may implicitly communicate that teaching is not a valued activity. While not observed in this study (where all studied programs had large pools of physics majors), weaknesses in the undergraduate physics program can deter students from the *major* (not just teaching careers).

Possible response: Recruitment from a pool of students in a physics-like major, such as engineering, can sustain a program when the number of physics majors is small. Improvements to the undergraduate physics program have been demonstrated to drastically increase the number of physics majors at some institutions (Hilborn, Krane, and Howes, 2003). Improvements to the introductory physics course may be particularly important for recruiting students both into the major and into teaching careers (Meltzer, Plisch, and Vokos, 2012; Seymour and Hewitt, 1997).

Physics faculty discourage physics teaching careers (3B)

Some physics faculty discourage physics teaching careers openly; others do so implicitly by assuming that all physics students want to go to graduate school or by suggesting that physics teaching is primarily for those who are not likely to succeed in graduate school. When these faculty are in advising roles, these views can heavily influence students.

Possible response: One response to this challenge is to make sure the physics department includes positive ambassadors for the teaching profession, preferably in advising roles (3B). Another is for the program to engage in widely visible recruitment mechanisms, such as early teaching experiences (3C) and recruitment from the introductory course (3B). Also, having physics faculty speak openly about how much they personally value teaching (at any level) can help to counter negative attitudes.

Programs miss opportunities for recruitment (3B)

Many physics teacher education programs rely on local factors (such as a large number of majors, proximity to a local high school, or high demand for teachers) to bring students into their program without actively seeking to increase the number of physics teacher candidates. Programs that draw from very large physics (or physics-aligned) major populations may even produce relatively high numbers of teachers this way. However, programs that do not actively recruit candidates are likely missing out on potential future teachers.

Possible response: Physics teacher education programs can benefit from the use of a variety of strategies for recruitment, including actively promoting the program and making sure advisors are aware of teaching careers (3B). Program promotion may include announcements in introductory courses, announcements in first-year student orientation, tabling at career fairs, sending letters to incoming and continuing students, and creating advertising materials and brochures. Student advising is an effective way to identify potential teacher candidates; getting accurate information to any faculty and staff involved in advising—including college advisors, the director of undergraduate studies, faculty advisors, and the career center—is key.

Time to degree and certification is too long (3D)

In many programs, the time needed to complete the required courses and certification activities is significant, which can deter some interested students from entering the program. One factor is credit load; the physics major itself is typically a credit-intensive degree program, and when added to the requirements in the

CU Teach students lead STEM activities at a K–12 outreach event. UNIVERSITY OF COLORADO BOULDER

school of education (particularly student teaching, during which students may be discouraged from or forbidden to enroll in other courses), completing all requirements in four years, for example, will at best take creativity and an early decision to pursue licensure. At worst, it may be impossible to complete the degree within four years, adding more tuition expense and time in school while not earning a salary. Lack of coordination between the physics and education departments can result in course sequence conflicts, which means that students have to wait a year for a course to be offered again. Some programs attempt to address this challenge by removing the more general education courses in order to maintain disciplinary content and pedagogy credits. However, this can cause friction between the physics teacher preparation program and the school of education, whose priorities may not be as focused on disciplinary preparation. Additionally, streamlining the licensure program for one area (such as physics or STEM) can be problematic for the school of education, which serves multiple disciplines and may not have the resources to create a special pathway for a few students.

Possible response: Departments may offer a physics teaching concentration that streamlines and prioritizes coursework for teacher candidates. Some physics departments offer a B.A. degree requiring fewer physics courses and allow physics teacher candidates to use physics teaching courses to fulfill elective requirements (Heron and McNeil, 2016). Discussions between the physics and education departments can be a good starting point to identify opportunities to streamline the student experience and remove unnecessary barriers to program completion. State-level advocacy can support the creation of streamlined certification pathways (6C). Statewide mandates or support from university administrators (1A) may bolster such efforts. Another strategy is to offer scholarships (e.g., from the NSF Noyce Program) or Teaching Assistant positions (with a tuition waiver) to provide financial support to students during the additional time required to complete the program (1C).

A future teacher shares her research at the UTeach Conference poster session. BRETT BUCHANAN

CHALLENGES ASSOCIATED WITH STANDARD 4: KNOWLEDGE AND SKILLS FOR TEACHING PHYSICS

Ineffective introductory physics course discourages students (4A)

A significant challenge for some physics teacher education programs is an unfavorable introductory physics course (4A), in which outdated and ineffective teaching methods may discourage students from careers in physics teaching. A high-quality introductory physics course provides potential physics teacher candidates with a positive vision of physics teaching and learning, including rich and robust physics content learning for themselves and great examples of physics teaching by departmental faculty.

Possible response: Physics education research provides many resources for improving the introductory physics course; see Chapter 4 for details. Workshops on research-based instruction, such as the Workshop for New Physics and Astronomy Faculty or those offered at AAPT meetings, provide opportunities for faculty to learn about research-based instruction. A growing number of physics departments implement Learning Assistant programs, which use peer instruction to improve student learning and support interactive curricula.

Physics pedagogy course is difficult to justify due to low enrollment (4B)

Physics pedagogy courses (4B) are important for students to develop physics-specific knowledge and skills for teaching, but they present multiple challenges for many programs. At most programs, the number of physics teacher candidates is small, making it difficult to meet the minimum enrollment requirements for courses offering discipline-specific teaching preparation. Even a science pedagogy course may not attract enough students to be sustainable. That challenge becomes even greater for programs attempting to offer core courses every semester in order to reduce candidates' time to degree. Even if a physics pedagogy course is offered regularly, teacher candidates may not be able to enroll in it due to credit-hour limits within their degree.

Possible response: A physics pedagogy course may be offered for Learning Assistants, undergraduate and graduate teaching assistants, in-service teachers, and teacher candidates to promote larger enrollments (4B; Vokos and Hodapp, 2015). Pedagogy courses may also include physics content, potentially making them relevant for and attractive to physics majors (4B). Early teaching experiences may count as pedagogy courses if they include sufficient intellectual content (3C; Vokos and Hodapp, 2015). Pedagogy courses may be offered as one-credit options to better fit into a packed degree program, or administrators may be convinced to lower the minimum number of students required to run the course, especially if they are sufficiently impressed with program outcomes and assessments (6B, 6C). In the absence of a physics pedagogy course, a Teacher in Residence can provide physics-specific mentorship associated both with a general science methods course (4B) and supervising student teaching (4D). Many resources for designing effective curricula for physics teacher candidates can be found in Chapter 4.

Research-based practices in physics teaching are difficult to find in cooperating schools (4B, 4D)

Physics teacher candidates should be prepared to teach physics using research-based teaching methods, but programs can experience challenges when these effective practices in physics teaching are not common in the local area (4B, 4D). For example, it can be difficult to find in-service teachers nearby who are using these same methods and who thus can effectively host future teachers wishing to use research-based teaching methods in their instruction. Additionally, it can sometimes be challenging for new teachers using research-based methods to find a school district that is receptive to non-traditional techniques.

Possible response: Teachers in Residence typically have an extensive network of colleagues and can help identify cooperating teachers with high-quality classroom environments. In programs with a long history, these challenges are more easily surmounted since the number of local graduates creates a large pool of high-quality cooperating teachers and since the reputation of the program creates a stronger market for its graduates (3A).

CHALLENGES ASSOCIATED WITH STANDARD 5: MENTORING AND PROFESSIONAL SUPPORT

Physics departmental advising is minimal (5A)

The best physics advising provides a clear roadmap of courses to accomplish different career goals and a structure in which majors are consistently mentored with their career options in mind. However, many physics departments lack strong structures for advising undergraduates; in these cases, advisors' limited attention goes mainly to students with specific problems.

Possible response: The report by the Joint Task Force on Undergraduate Physics Programs, *Phys21* (Heron and McNeil, 2016), includes excellent recommendations for effective advising, such as having a consistent advising plan in the department, requiring periodic advising appointments, and providing coaching to faculty to improve their mentoring and advising skills.

Program alumni are minimally supported (5C)

Ideally, a physics teacher education program monitors and supports teacher graduates to retain them in the profession and support the development of their physics teaching expertise. However, physics teacher education programs often have limited resources such that the program leaders cannot devote much time to in-service mentoring and professional community.

Possible response: Thriving programs that effectively support their alumni often do so in collaboration with a professional group for local physics teachers. These groups can be an important source of networking and support for new teachers. They may meet in person monthly or several times a year, preferably with professional development credit available to participants. Social media provides another opportunity for program graduates to connect to each other and to other physics teachers.

CHALLENGES ASSOCIATED WITH STANDARD 6: PROGRAM ASSESSMENT

Metrics are difficult to track and analyze (6A, 6B)

Metrics in physics teacher education are difficult to track, both because students transition out of various parts of the program and because the metrics themselves may be slippery. For example, in some programs it is hard to count the number of students recruited into physics teaching in a given year because there is no official distinction between students “in the program” and students participating in program elements such as early teaching experiences. Career persistence is similarly important but difficult to define. Other challenges include fluctuations in small numbers, which make it hard to see patterns, and data that comes from multiple sources, which is difficult to both gather and analyze. Some programs gather data about physics teacher education but find it challenging to make time to analyze or reflect on it for purposes of program improvement.

Possible response: Programs can make progress by deciding what they wish to track (e.g., recruitment by year, program completion by year, time to degree), setting specific recurring times to gather data, and charging one team member with collecting and analyzing the data. Other units, such as the school of education, may already be gathering relevant data that can be leveraged. For new data, it can help to start with a relatively simple assessment, such as a brief survey of alumni. Several resources for program assessment are included in Chapter 4.

Program team does not consistently communicate with stakeholders (6C)

Communication with stakeholders, such as higher administrators and other academic units, may not be understood by program leaders to be important, and faculty may not make time to cultivate relationships with stakeholders. In addition, some faculty may not have direct access to higher administrators or may not understand principles of effective communication with stakeholders.

Possible response: Programs wishing to meet this challenge need to recognize the time and skill it takes for faculty to cultivate relationships with administrators and leaders of other academic units. Programs should establish regular channels for quality communication, such as having program team members present data at meetings or having them regularly meet with a chair. Gathering and analyzing quality assessment data (6B) can support communication with stakeholders. Program leaders can increase their perceived value by regularly communicating program successes and proving talking points to administrators; in addition, program leaders should seek both to understand the issues faced by administrators and to frame their requests as solutions to these issues.

SUMMARY

Many challenges have been observed among the thriving programs in achieving PTEPA Rubric standards and components, even in areas where the programs eventually achieved success. The PTEPA Rubric structure allows systematic categorization of these challenges. Many existing resources provide strategies for improvement.

CHAPTER 6

How Can You Use the PTEPA Rubric, and What Do Your Results Mean?

The PTEPA Rubric supports physics teacher education programs in identifying strengths and gaps in their programs, assisting in program improvement.

INTRODUCTION

Completing the Physics Teacher Education Program Analysis (PTEPA) Rubric can guide self-reflection toward program improvement and characterize program growth. If you are a leader of a physics teacher education program, PTEPA Rubric results may support you in celebrating successes, identifying program gaps, and arguing for resources to meet program needs.

The PTEPA Rubric has been developed to measure features that thriving physics teacher education programs tend to have. Completing the PTEPA Rubric will help you to measure your program's degree of similarity to thriving programs. This may indicate the extent to which you can expect your program to successfully recruit, educate, and professionally support large numbers of physics teachers, though this interpretation has not yet been substantiated by research. A suggested path to program improvement is to identify and address gaps between what your program achieves and what thriving programs tend to achieve on the PTEPA Rubric.

The PTEPA Rubric measures features of *physics* teacher education programs. Teacher education programs without an interest in physics-specific teacher preparation may not find the PTEPA Rubric to be well suited to their activities and structures. Similarly, integrated *science* teacher education programs will find that many PTEPA Rubric items are not relevant to their program goals.

PTEPA RUBRIC FORMATS

The PTEPA Rubric is available in a fixed format (fillable PDF) or as an interactive spreadsheet (Excel).[1] A sample from the fixed-format version is shown in Figure 13, and a sample from the interactive spreadsheet is shown in Figure 14. The interactive spreadsheet is the recommended format, given that it allows for automated visualization of the results; however, you may wish to use the PDF format if you want a paper copy of the rubric (for example, to be distributed at an in-person meeting to complete the rubric or discuss results) or if you experience technical difficulties with the interactive spreadsheet.

Figure 13: Sample from the PTEPA Rubric (fixed-format version).

Standard 2 **Leadership and Collaboration**

The program has an effective leadership team, including effective collaboration between physics and education.

2A: Program Team Members

The program consists of a team[1,2] whose members are in positions that enable effective leadership.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
2A-1 **PTE program leaders[1]** PREVALENT	☐	☐ Program leaders include at least one faculty member.	☐ Program leaders include two faculty members.	☐ Program leaders include three or more faculty members.
2A-2 **PTE program team[2]** PREVALENT	☐	☐ Team consists of one person in addition to the leader(s).	☐ Team consists of two people in addition to the leader(s).	☐ Team consists of at least two people in addition to the leader(s), at least one of whom is a faculty member.
2A-3 **Teacher in Residence (TIR)[3]** PREVALENT	☐	☐ There is a part-time physics TIR, or there is a science TIR (at any FTE).	☐ There is one FTE physics TIR.	☐ There is more than one FTE physics TIR.
2A-4 **Teacher Advisory Group (TAG)[4]**	☐	☐ There is a science TAG.	☐ There is a physics TAG (significant physics teacher membership).	☐ There is a physics TAG that is readily available for consultation by the PTE team.

A single component of the PTEPA Rubric in the fixed-format (fillable PDF) version. Prevalent items are highlighted, and the user can mark the checkboxes.

Figure 14: Sample from the PTEPA Rubric (interactive spreadsheet version).

Standard 2 **Leadership and Collaboration**

The program has an effective leadership team, including effective collaboration between physics and education.

Component 2A: Program Team Members

The program consists of a team[1,2] whose members are in positions that enable effective leadership.

		NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
2A-1	PTE program leaders[1] PREVALENT	○	○ Program leaders include at least one faculty member.	○ Program leaders include two faculty members.	◉ **Program leaders include three or more faculty members.**
2A-2	PTE program team[2] PREVALENT	○	○ Team consists of one person in addition to the leader(s).	◉ **Team consists of two people in addition to the leader(s).**	○ Team consists of at least two people in addition to the leader(s), at least one of whom is a faculty member.
2A-3	Teacher in Residence (TIR)[3] PREVALENT	○	◉ **There is a part-time physics TIR, or there is a science TIR (at any FTE).**	○ There is one FTE physics TIR.	○ There is more than one FTE physics TIR.
2A-4	Teacher Advisory Group (TAG)[4]	○	○ There is a science TAG.	◉ **There is a physics TAG (significant physics teacher membership).**	○ There is a physics TAG that is readily available for consultation by the PTE team.

A single component of the PTEPA Rubric in the interactive spreadsheet version. Prevalent items are highlighted, and the items that are selected by the user (using radio buttons) are shaded blue.

The PTEPA Rubric is provided in Appendix A1, and the PTEPA Rubric Snapshot provides a shortened overview of the instrument. See http://phystec.org/thriving for the most recent copies of both documents.

In either format, select the most appropriate level on each PTEPA Rubric item for describing your program—Not Present (NP), Developing, Benchmark, or Exemplary—using checkboxes or radio buttons.

PROCESS OF COMPLETING THE PTEPA RUBRIC

The PTEPA Rubric is a substantial instrument, with about 100 items. This reflects the fact that programs achieve excellence in many different ways, and the instrument is designed to be inclusive as evidence accumulates about which program elements are most essential. You can expect it will take 2–3 hours to complete the self-analysis, depending on your level of knowledge about the program. Completing the PTEPA Rubric for your program will likely involve significant reflection as well as discussions with program team members and other personnel.

Resources (in the form of worksheets and handouts) to support PTEPA Rubric completion are provided in Appendix A2, including those shown in the call-out box below.

The following steps are recommended for completing the PTEPA Rubric:

1. Prepare

Determine your preferred process for completing the instrument and involving stakeholders. Consider completing the PTEPA Rubric collaboratively with your team as an interactive "PTEPA Party" (see Appendix A2-1 for details and structure), using a couple of shorter meetings or a longer retreat or by assigning sections of the rubric to different groups. The rubric can best support program improvement when a variety of stakeholders are involved (Ewell and Jankowski, 2015). PhysTEC evaluators are also available as coaches for your group.

Complete the brief informational questions in Appendix A2-2 (also in the interactive version of the PTEPA Rubric) to define terms, identify stakeholders, and gather needed background information about your program.

2. Complete the instrument

In a group or individually, select the most appropriate level for describing your program for each PTEPA Rubric item (see call-out box on page 54).

For items that are in no way applicable to that program (e.g., "Post-baccalaureate certification" for a program that does not offer a post-baccalaureate option), the item should be left blank. "NP" is only for the absence of an item, not for a non-applicable item.

Resource	Purpose
(A2-1) PTEPA Party Handout	This handout describes various group processes for completing the PTEPA Rubric and interpreting results.
(A2-2) Informational Questions	A list of stakeholders whom you may need to consult for completing the PTEPA Rubric, along with information-gathering questions for each.
(A2-3) Importance and Synthesis Ratings	Rating scales and a table that allow you to rate the importance of PTEPA Rubric elements for your program and interpret your ratings as a whole.
(A2-4) PTEPA Rubric Narrative Self-study Template	An outline of a document to describe your program's strength and gaps on the PTEPA Rubric, what you have learned, and your plan of action.

Figure 15: Item-level rating report.

Standard 2: Leadership and Collaboration				
Component 2A: Program Team Members				
2A-1	PTE program leaders	EXEMPLARY	★★★	Program leaders include three or more faculty members.
2A-2	PTE program team	BENCHMARK	★★☆	Team consists of two people in addition to the leader(s).
2A-3	Teacher in Residence (TIR)	DEVELOPING	★☆☆	There is a part-time physics TIR, or there is a science TIR (at any FTE).
2A-4	Teacher Advisory Group (TAG)	BENCHMARK	★★☆	There is a physics TAG (significant physics teacher membership).

An item-level rating report from Component 2A, from the interactive spreadsheet version of the rubric.

As you are completing the ratings, identify the evidence for each of your ratings to support interpretation of these ratings.[2] Add comments to document your rationale for each response or indicate areas of uncertainty.[3]

You will likely need to gather data from all the stakeholders in your program, such as faculty leaders, the program team, physics teacher candidates, Teachers in Residence, administrators, cooperating teachers, program graduates, and others who may have a perspective on the items in the PTEPA Rubric (see Appendix A2-2 for a list of possible stakeholders and interview questions).

Level	Description
Not Present (NP)	Item is not present in the program.
Developing	The program performs better than a typical U.S. institution of higher education on that item.
Benchmark	The program performs at a recommended level on that item.
Exemplary	The program is among the best-performing on that item.

3. Interpret the results

You should not expect your program to rate Exemplary on a majority of items; even the thriving programs studied rated Exemplary on only 35–68% of all items. Although Benchmark is the recommended level of performance, the thriving programs studied also had many PTEPA Rubric responses below this level (up to 16% of items rated as NP and up to 21% of items rated as Developing; see Chapter 3). Remember that even the Developing level represents more than a typical institution of higher education will achieve.

You should also not expect your program to rate Benchmark on all items, since not all items are important for every physics teacher education program. Best practices are context dependent; physics teacher education programs need to adapt their activities and structures to their individual goals, environments, resources, and constraints. A good place to start is with the Prevalent items. The more strength your program has in Prevalent items, the more it shares features that are highly common among thriving programs. Keep in mind that items that are not Prevalent may still be important for your specific program.

We suggest identifying gaps at the item and component level rather than the standard level, given that even thriving programs demonstrated variable levels of achievement on items and components within the larger standards. Items and components also represent more directly actionable program elements. Identify items for which your program does not meet the Benchmark

Figure 16: “Heat map” visualization of PTEPA Rubric results.

	NP	DEVELOPING	BENCHMARK	EXEMPLARY
All PTEPA Standards	12%	21%	33%	34%
Standard 1: Institutional Commitment	7%	36%	50%	7%
Component 1A: Institutional Climate and Support	0%	33%	50%	17%
Component 1B: Reward Structure	0%	100%	0%	0%
Component 1C: Resources	20%	0%	80%	0%
Standard 2: Leadership and Collaboration	19%	19%	23%	58%
Component 2A: Program Team Members	0%	25%	50%	25%
Component 2B: Program Team Attributes	22%	33%	13%	76%
Component 2C: Program Collaboration	25%	0%	25%	50%

A “heat map” visualization of PTEPA Rubric results from the interactive spreadsheet version, which shows the percentage of items in the standard (or component) that reach each level (NP, Developing, Benchmark, or Exemplary) for the rubric as a whole (first row) and the first two standards (subsequent rows). White cells indicate fewer than 25% of items are at the given level, the lightest shade indicates 25–49% of items at that level, the medium shade indicates 50–75% of items at that level, and the darkest shade indicates 75–100% of items at that level.

level and components for which many items are rated below the Benchmark level, and then use a contextualized understanding of your program to consider whether these constitute important gaps to be addressed.

Gap analysis is supported by the interactive PTEPA Rubric. The interactive rubric contains several automatic visualizations providing a synthesis across standards. Figure 15 shows a section of a report showing item ratings across the rubric, allowing identification of lower-performing items. Figure 16 shows a “heat map” visualization of results across components and standards, allowing visualization of relative program strength across these elements.

Synthesizing your results will help to support program improvements. While it is not appropriate to assign numerical scores to overall PTEPA Rubric results (see “Cautionary note on comparing programs” below), many programs will want to have a sense of how well they did on the rubric as a whole. Some options to accomplish this include the following:

- If you are using the interactive spreadsheet version of the PTEPA Rubric, the “heat map” visualization allows you to identify components and standards that are strong as well as those that may be in need of improvement (see Figure 16).
- A worksheet for “Importance and Synthesis Ratings” is provided in Appendix A2-3. It includes an “importance” rating to indicate the relative importance of each component and standard for your program. The “synthesis” rating allows you to indicate whether you consider your program’s achievement on the PTEPA Rubric to be adequate for each component and standard and to track results over three years.
- As a culmination of program analysis, the “PTEPA Rubric Narrative Self-study Template” provided in Appendix A2-4 can guide you in writing a narrative self-study report, which includes a growth and improvement plan.

4. Communicate the results

Share your data and interpretations with your program team and other stakeholders to enable reflective discussion. In order for communication to have maximal impact, consider the interests of your specific audience, frame your findings and messages around those interests, and provide adequate context for your message to be understood (Jankowski and Cain, 2015; Olson, 2009). Recommended practices include:

Address the needs and interest of the audience. Information is most useful when it’s presented in a way that is

A Learning Assistant works with the pedagogy course instructor as they discuss a physics experiment. CHICAGO STATE UNIVERSITY

tailored to be relevant to a particular audience, preferably at a time when they need that information to make decisions. Your results will be more compelling, for example, if you explain their relevance to the college's strategic plan or show how your work helps to address a problem (such as low enrollments) facing the administration.

Do not assume that the data "speak for themselves." You can (and should) provide a meaningful framing and interpretation for the data. Engage in "evidence-based storytelling" about your program, using rubric or other data to support your claims and to persuade a particular audience (for example, about program successes or a need for further resources or structure).

Use multiple formats for your communication, such as reports, emails, meetings, presentations, brochures, websites, white papers, and so on. The point is not to provide more information through various formats but to target different audiences through different mechanisms and provide opportunity for reinforcement of messages through multiple means. Consider asking external stakeholders, such as the PhysTEC project, to write a letter to key university administrators about program successes and impact.

Use effective data presentation, including simple visual displays that are easy for the audience to process and that highlight key points. Respect your audience's time and reduce their burden in interpreting your results. A short, one-page document with bulleted talking points and one or two figures with key results can be effective for communicating with administrators who have limited time.

If creating written reports on your rubric (and other assessment) results, define the purposes of the report, identify likely audiences for that report, and use effective practices (such as clear actionable headings and short sentences) to best communicate your message.

Chapter 4 discusses how thriving programs communicate program data to stakeholders. Please also consider providing your completed PTEPA Rubric and narrative self-study to the PhysTEC project for research purposes.[4] See Chapter 7 for more information on the research agenda.

5. Use results for continuous improvement

Completion of the PTEPA Rubric will be most useful when it contributes to continuous improvement of the program. A focus on data-driven improvement is critical for teacher education programs and other initiatives in higher education (Heron and McNeil, 2016; Coble, 2012; Council for the Accreditation of Educator Preparation, 2016; Kezar, 2014). Program review is most likely to contribute to such improvement when it is done continuously, when it contributes to institutional processes, when it is understood as part of a process of program improvement, and when the data is used to stimulate conversations in the program about outcomes and strategies (Ewell and Jankowski, 2015). These goals can be met by completing the PTEPA Rubric once per year at strategic times, such as:

- During program planning meetings.
- When preparing annual reports.
- When preparing to make a case for program resources.
- When preparing a talk or presentation.
- During department strategic planning.
- During department or college retreats.

Cautionary note on comparing programs

Rubrics represent a complex entity (such as a physics teacher education program) in terms of a number of discrete elements (in this case, the elements of the PTEPA Rubric), each with its own rating. As a consequence, the PTEPA Rubric may create the expectation that physics teacher education programs can be quantitatively compared with each other (for example, it may suggest that one program is twice as good as another if it gets twice as many Exemplary ratings). However, elements of the PTEPA Rubric are neither independent nor of equal weight. Thus, one should not turn PTEPA Rubric results into numerical "scores" for comparing programs. One also cannot say that a program that has 60% of its items rated as Exemplary is definitively better than one that shows 50% rated as Exemplary or that two programs that have equal PTEPA Rubric results are equally good. The interactive Excel version provides several visualizations to help you interpret results without assigning numeric values.

The fact that we cannot reliably interpret a numerical overall program "score" on the PTEPA Rubric (or use such a single score to quantitatively compare programs) has to do with the variety of thriving physics teacher education programs. There is not a single linear hierarchy of increasingly high-quality physics teacher education programs; instead, there are diverse program types suited to different local conditions. Physics teacher education programs need to adapt their activities and structures to their individual goals, environments, resources, and constraints. The PTEPA Rubric is intended as a comprehensive outline of elements for physics teacher education programs to consider, but it is *not* a checklist of universal standards that all physics teacher education programs must follow. Rather, individual programs are expected to prioritize growth in areas appropriate to their institutional settings, regional contexts, and expertise of personnel.

A Master Teacher and a teacher coach participate in a hands-on activity during a workshop. BRETT BUCHANAN

SUMMARY

Completing the PTEPA Rubric is a substantial process of self-analysis for physics teacher education programs. The goal of completing the PTEPA Rubric for your program is to guide self-reflection toward improvement and characterize program growth. The guidance in this chapter is designed to help programs complete the rubric and interpret their results appropriately.

ENDNOTES

1 Claudia Fracchiola, PhD, contributed significantly to the design of the interactive spreadsheet and visualizations.

2 As a supplemental option, there are a number of existing assessments and resources that may support you in evaluating specific aspects of your program (e.g., PhysTEC's assessment page, the National Council on Teacher Quality site, the Teacher Preparation Analytics Key Effectiveness Indicators); these are listed in Chapter 4 of this report.

3 Note that specific program team members may fill multiple roles and therefore may appear in a number of different items in the rubric. It is not appropriate to limit the influence of personnel to a single item if they fill multiple roles. For example, a Teacher in Residence may be included in several items, and a staff member or team member might also count as a Teacher in Residence.

4 Email phystec@aps.org to share your data.

CHAPTER 7

What Should Come Next?

Development and analysis of the PTEPA Rubric suggest multiple avenues to improve its utility for program feedback, research, and systematic improvement of physics teacher education.

RECOMMENDATIONS FOR PHYSICS TEACHER EDUCATION PROGRAMS

The Physics Teacher Education Program Analysis (PTEPA) Rubric is intended to provide physics teacher education programs with feedback, to guide programs in self-reflection toward improvement, and to provide a means to characterize program growth.

1. Complete the PTEPA Rubric

A strong recommendation is for programs to complete the PTEPA Rubric and consider sharing the results to contribute to research. PTEPA Rubric results may support programs in celebrating successes, identifying program gaps, and arguing for resources to meet program needs. Chapter 6 of this report describes how to complete and interpret the rubric, and Appendix A2 offers supportive worksheets and questionnaires to support this process.

2. Consider aligning features with thriving programs

In general, PTEPA Rubric results for a physics teacher education program indicate the extent to which that program has the same features as thriving programs. This may indicate the extent to which one can expect a program to successfully recruit, educate, and professionally support large numbers of physics teachers, though this interpretation has not yet been substantiated by research. Until such research results are available, a reasonable path to program improvement is to address weaknesses on the PTEPA Rubric—in other words, to identify and make efforts to close gaps between what the program achieves and what thriving programs tend to achieve. However, programs should keep in mind that not all PTEPA Rubric elements are important for every physics teacher education program. Best practices are context dependent; physics teacher education programs need to adapt their activities and structures to their individual goals, environments, resources, and constraints.

A Learning Assistant facilitates student discussion during a physics lecture. CRAIG TERRY

3. Engage in continuous improvement

The PTEPA Rubric will best support program growth and improvement if it is completed periodically, such as during program or departmental review, so that it stimulates regular conversation about outcomes and strategies (Ewell and Jankowski, 2015). Completing the PTEPA Rubric annually can support your program in the kind of data-driven improvement that is crucial for successful initiatives in higher education (Heron and McNeil, 2016; Coble, 2012; Council for the Accreditation of Educator Preparation, 2016; Kezar, 2014). As part of such a regular review process, programs should recognize challenges to be faced and address or avoid them as they are able (see Chapter 5).

RECOMMENDATIONS FOR RESEARCHERS

Researchers should conduct activities to expand the validity of the PTEPA Rubric and to investigate research questions that would support and refine interpretation of results.

1. Expand validity

Like all validation, the validation of the PTEPA Rubric is hypothesis specific. In this study, the hypothesis investigated for the PTEPA Rubric is that the PTEPA Rubric measures features that thriving programs tend to have. For a more in-depth discussion of PTEPA Rubric validation, see Chapter 2.

Further validation might include investigation of other hypotheses related to the PTEPA Rubric. Doing so promises to extend the validity of the PTEPA Rubric and aid interpretation. Some possible questions for future investigations include:

Are different PTEPA Rubric results associated with different rates of physics teacher production?

Investigating this question would require studying data from programs that have fewer physics teacher graduates as well as those that have many in order to test the PTEPA Rubric's ability to discern between different levels of teacher production.

Does increasing a program's PTEPA Rubric results lead to an increase in its number of teacher graduates?

Investigating this causal question would require administering the PTEPA Rubric at different points in time or retrospectively for a program that had experienced such a change and analyzing whether change in the PTEPA Rubric results corresponds to change in the number of teacher graduates.

Are certain elements of the PTEPA Rubric particularly essential?

The PTEPA Rubric is a long instrument, reflecting the fact that programs achieve excellence in many different ways. It would be a benefit to learn whether certain standards, components, or items are particularly essential to a thriving physics teacher education program and if this varies by context. Research conducted so far identifies some items as Prevalent, meaning that six of the eight studied programs (75%) achieved at least the Benchmark level on that item; this is one approach to identifying the most important items (or components or standards). However, it would be even more valuable to determine whether certain elements of the rubric predict high teacher graduation rates (i.e., *predictive validity*).

Are there missing elements in the PTEPA Rubric?

There are aspects of physics teacher education that are not represented in the PTEPA Rubric, and research is needed to learn whether they ought to be included (at the standard, component, or item level). For example, alignment with the Next Generation Science Standards, commitment to physics learning for all students (National Research Council, 2013), and local working conditions for physics teachers are a few such non-included aspects identified by expert review. More thoroughly answering the question of missing elements would further mitigate two common threats to validity: (1) inadequate preoperational explication of constructs (did the researchers define the key concepts well enough before creating the rubric?) and (2) interaction of different treatments (do physics teacher education programs benefit from activities not included in the rubric, meaning that something else explains their status as thriving programs?).

2. Expand the knowledge base

The PTEPA Rubric is intended to support research on physics teacher education programs, allowing comparison of different programs, aggregation of information on activities across programs, and investigation of how common features of programs and practices correlate with physics teacher graduation rates. Future investigations may include the following:

Are certain elements of the PTEPA Rubric particularly important for teacher production?

As described above, the most desirable area of PTEPA Rubric research would link specific rubric elements (standards, components, or items) to high teacher graduation rates. Such *predictive validity* would allow the rubric to provide significant guidance to teacher education programs. Research along these lines might eventually support identifying some PTEPA Rubric items as "mandatory" items that should be achieved at a certain level for all programs (this approach was recommended by an external review of accreditation processes; see Appendix A4).

Do certain elements of the PTEPA Rubric tend to appear together?

If so, this would suggest that those elements (whether standards, components, or items) are related to one another, meaning that having one tends to support having the others. Such cluster analysis could also help investigate patterns of response when programs have particular features, such as a Teacher in Residence (TIR) or a program leader located in the school of education; for example, it may be that having a TIR is associated with other strengths, such as "K–12 school engagement" and having a "ambassador" for the teaching profession.

Are there common patterns of PTEPA Rubric results?

If PTEPA Rubric results could be used to identify distinctive types or "profiles" of physics teacher education programs, perhaps associated with particular institutional or program types, it might help programs to identify sets of activities or approaches appropriate to their program type or institutional context.

Does the PTEPA Rubric help distinguish between different contexts for and models of physics teacher education?

In conjunction with analysis of graduation numbers, PTEPA Rubric analysis might help to characterize the differences between different types of programs and identify their most important elements. For example, the rubric might allow comparisons between program locations (physics department versus schools of education), models (UTeach versus PhysTEC), types of institution (liberal arts institution versus research university), or broader contexts (states with composite certification versus single-subject licensure). In some cases, rubric items may need to be modified to better account for different contexts, especially where item levels indicate numbers that would not be achievable at smaller institutions (e.g., number of physics majors or amount of institutional funding).

What should a particular physics teacher education program prioritize in order to support the highest possible teacher graduation rate?

One goal of this project is to help programs select program activities and direct resources toward this desired outcome. Addressing the above research questions would help the community move toward satisfactory answers to this pressing question.

RECOMMENDATIONS FOR PHYSTEC

1. Test and improve usability

The PTEPA Rubric has been tested with a small number of users—mainly the program leaders at the eight studied thriving programs—who used it with extensive support from the research team. An important part of future PTEPA Rubric development will be *usability testing* (evaluating the PTEPA Rubric by testing it with representative users). In a PTEPA Rubric usability study, program leaders will complete the PTEPA Rubric while researchers document their experience. The goal will be to identify usability problems and collect data to learn the extent to which the PTEPA Rubric is useful for self-study and for program improvements.

2. Create supportive policies and incentives

As recommended in earlier reports (e.g., Meltzer, Plisch, and Vokos, 2012; sources in Appendix A4), professional societies should provide support, intellectual leadership, and a coherent vision for physics teacher education. The PTEPA Rubric can provide specific avenues for pursuing this general effort.

PhysTEC should promote the above research to further validate the PTEPA Rubric and put it to use for answering key research questions (Meltzer, Plisch, and Vokos, 2012). This should include supporting personnel to conduct research and share their findings through presentation and publication. Future research may support PhysTEC in making statements supporting specific physics teacher program elements (for example, those that correspond to PTEPA Rubric standards or components) and calling on programs to use the PTEPA Rubric to measure their performance on these elements.

PhysTEC should consider ways to promote the use of the PTEPA Rubric, especially by using strategies that have been employed in accreditation processes (see Appendix A4). Some options include:

- Requiring periodic PTEPA Rubric completion, including narrative self-analysis of program strengths and weaknesses and a rubric-based improvement plan, for programs with PhysTEC site awards.
- Providing resources—such as publications, workshops, webinars, new and improved tools to aid implementation, and advising by experts—to physics teacher education programs completing the PTEPA Rubric.
- Creating a "PTEPA prize" or other incentive for sustained or newly achieved excellence on the PTEPA Rubric.
- Offering scholarly opportunities, such as the chance to present at conferences or webinars, to leaders of programs that demonstrate strength in certain PTEPA Rubric elements.

SUMMARY

The PTEPA Rubric is at the beginning of its development as a tool for feedback, research, and systematic improvement of physics teacher education programs. Future research efforts should focus on increasing its validity and expanding the associated knowledge base. PhysTEC should promote broad use of the PTEPA Rubric and seek to maximize its usability.

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Appendices

APPENDIX 1

Physics Teacher Education Program Analysis (PTEPA) Rubric

A rubric to describe and guide physics teacher education programs

The purpose of the Physics Teacher Education Program Analysis (PTEPA) Rubric is to characterize physics teacher education programs. The PTEPA Rubric emphasizes elements that have been observed in "thriving" physics teacher education programs (programs at large universities that typically graduate five or more physics teachers in a year). It is intended to provide programs with feedback, to guide programs in self-reflection toward improvement, and to provide a means to characterize and research program growth.

This version of the PTEPA Rubric (1.2) reflects the version of the instrument that is described in this report.

For the most recent version of the PTEPA Rubric and the PTEPA Rubric Snapshot, please visit: http://phystec.org/thriving.

Contents

Definitions of Terms Used in PTEPA Rubric *(in the order in which they appear)*

Physics teacher education (PTE) program Either the formal named physics teacher education program (e.g., UTeach) or the informal collection of (1) courses and experiential learning opportunities for teachers with physics-specific content and (2) people (instructors, leaders) who directly serve physics teacher candidates.

PTE program leaders Those faculty members (tenure or non-tenure track) or administrators in physics or science education (or similar unit responsible specifically for PTE) who spearhead the program, advocate for resources such as funding and personnel, and negotiate with the institution for changes beneficial to physics teacher education.

PTE program team A team consisting of the program leaders plus other personnel who are responsible for the daily operation of the PTE program.

Teacher in Residence A person with exemplary understanding of teaching and experience teaching in K–12 schools who functions as an essential colleague to the PTE program.

Early teaching experiences Those teaching experiences intended to give first- and second-year students experience with teaching, such as sustained tutoring, sustained outreach, Learning Assistant opportunities, and UTeach “Step 1” or other entry-level courses, among other possibilities.

Physics teacher candidate A student who has committed to completing a program of physics teacher education.

Physics pedagogy credits Credits earned either through (1) completing a standalone course devoted to physics teaching and learning, or (2) completing a science methods or other course that has a component about physics teaching and learning (in which case only a fraction of course credit is considered as physics pedagogy).

Science methods course A standalone course exploring techniques in science instruction, taught in the School of Education.

Field experience An in-classroom K–12 teaching experience for teacher candidates, preferably in a physics or physical-science classroom with an on-campus course component. The goal of a field experience is to put education coursework into practice in a school setting by teaching (or helping to teach) a pre-college class.

Student teaching A capstone field experience in which a teacher candidate teaches in a K–12 setting with full control of multiple classes for at least a semester, fulfilling licensure requirements.

Cooperating teacher A certified teacher (preferably a physics teacher) who hosts and supervises student teaching experiences at a school, as part of field experiences or student teaching.

University supervisor A member of the university faculty with expertise in teacher education who is the instructor of record for the student teaching experience, which includes observing and supporting teacher candidates during student teaching.

PTE mentor A faculty member who specializes in physics teacher education, a TIR, or a local teacher who is able to provide mentoring in careers, skills, and teaching development (not just academic advising).

Acronyms

A&S College of Arts & Sciences or equivalent
FTE Full-Time Equivalent
LA Learning Assistant
PTE Physics Teacher Education
SoE School of Education or equivalent
STEM Science, Technology, Engineering, and Mathematics
TA Teaching Assistant
TIR Teacher in Residence

PTEPA Rubric Item Definitions

NP Not present in the program.
Developing Program is making progress towards meeting a typical goal for this item.
Benchmark Program meets a typical goal for this item.
Exemplary Program goes well beyond a typical goal for this item.
Prevalent Majority of studied sites achieved Benchmark level on the item.

Standard 1 Institutional Commitment

There is a strong institutional commitment to STEM teacher education, supported by policy, rewards, and financial resources.

1A: Institutional Climate and Support

There is a strong institutional commitment to science, technology, engineering and math (STEM) teacher education, with physics teacher preparation as an explicit component.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
1A-1 **University-level support[1] for STEM education** PREVALENT	☐	☐ President- or provost-level administration verbally prioritizes STEM educational improvements, but as yet there is little to no evidence of this support.	☐ Additionally, there is evidence of university support for STEM education improvements.	☐ There is concrete support from the university for STEM education improvements.
1A-2 **Institutional mission of teacher education** PREVALENT	☐	☐ The institutional mission and/or strategic priorities historically support teacher education.	☐ The institutional mission or strategic priorities are explicitly well aligned with teacher preparation (e.g., an emphasis on service).	☐ Institutional administrators emphasize publicly and consistently that teacher preparation is part of the core institutional mission and strategic priorities are explicitly well aligned with teacher preparation.
1A-3 **Administrative recognition for physics teacher education (PTE) program[2]** PREVALENT	☐	☐ The PTE program has received modest recognition from administrators (e.g., department-level recognition, being mentioned in meetings).	☐ The PTE program has received significant public recognition from administrators (e.g., public remarks, campus newsletter, college website).	☐ The PTE program is a point of pride for the institution, and its work is publicly recognized in several venues.
1A-4 **University-level support[1] for teacher education**	☐	☐ President- or provost-level administration verbally prioritizes teacher education, but as yet there is little to no evidence of this support.	☐ Additionally, there is evidence of university administration support for teacher education.	☐ There is concrete support from the university administration for teacher education.
1A-5 **Arts & Sciences (A&S)[3]–level support[1] for teacher education**	☐	☐ The Dean of the College of A&S verbally prioritizes teacher education, but as yet there is little to no evidence of this support.	☐ Additionally, there is evidence of A&S support for teacher education.	☐ There is concrete support from A&S for teacher education.
1A-6 **School of Education (SoE)[4]–level support[1] for physics teacher education**	☐	☐ There is some evidence of SoE support for *science* teacher education.	☐ Additionally, there is some evidence of SoE support for *physics* teacher education.	☐ There is concrete support from the SoE for *physics* teacher education.

1B: Reward Structure

The institution encourages, supports, and rewards leadership in physics teacher preparation.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
1B-1 **Promotion and tenure in physics**	☐	☐ At least one physics faculty member is given credit toward promotion based on their work in PTE.	☐ At least one physics faculty member has been hired in large part based on their PTE expertise.	☐ At least one tenure-track physics faculty member has been promoted in large part based on their PTE activities.
1B-2 **Time for PTE program leaders[5] to engage**	☐	☐ Physics teacher preparation is officially included as part of service for PTE program leader(s).	☐ PTE program leader(s) have received modest time to engage in PTE activities.[6]	☐ PTE program leader(s) have received significant time to engage in PTE activities.[6]
1B-3 **Recognition for PTE program team[7]**	☐	☐ Modest recognition[8] is provided to members of the PTE program team for engaging in PTE.	☐ Members of the PTE program team have been nominated for awards[9] during the past five years based on their PTE activities.	☐ The department or institution celebrates PTE activities through significant public recognition in the last three years.

Continued

Standard 1 Institutional Commitment

1C: Resources

The program and leadership team have sufficient resources to run.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
1C-1 **Engaged staff**[10] PREVALENT	☐	☐ Less than 0.5 full-time equivalent (FTE) engaged staff.	☐ 0.5–1.0 FTE engaged staff.	☐ More than 1 FTE engaged staff.
1C-2 **Institutional funding**[11] PREVALENT	☐	☐ Institutional funding is at least $5K.	☐ Institutional funding is $25K–$100K/year.	☐ Institutional funding exceeds $100K/year.
1C-3 **External funding** PREVALENT	☐	☐ External funding is less than $25K/year.	☐ External funding is $25K–$100K/year.	☐ External funding exceeds $100K/year.
1C-4 **Stability of program operational funding**[12]	☐	☐ Operational funding has been historically granted but occurs on a year-to-year basis.	☐ Operational funding is guaranteed for at least three years.	☐ Operational funding is a recurring line item or is supported by ongoing endowments.
1C-5 **Program space**	☐	☐ The program is housed in a faculty office with a clear program label.	☐ The program has a dedicated space.	☐ The program has dedicated space in a location frequented by physics students.

1 **Evidence of support** for education (STEM, teacher, or physics teacher) could encompass regular inclusion in strategic planning, public declarations of need for programs or educational change, verbal protection of the program, inclusion in or strong alignment with an explicit mission statement, a long-term plan, the School of Education (SoE) providing a science licensure program, and so on. **Concrete support** includes policies, funding and/or space for programs, positions, an institute, and the like.

2 The **Physics Teacher Education (PTE) program** is either the formal named physics teacher education program (e.g., UTeach) or the informal collection of (1) courses and experiential learning opportunities for teachers with physics-specific content and (2) people (instructors, leaders) who directly serve physics teacher candidates. The program should include a presence in the physics department but need not be run out of the physics department.

3 **Arts & Sciences (A&S)** or other academic unit that includes physics and other related disciplinary departments.

4 **School of Education (SoE)** or other academic unit that is charged with teacher education.

5 **PTE program leaders** (also called champions) are those faculty members (tenure or non-tenure track) or administrators in physics or science education (or similar unit responsible specifically for PTE) who spearhead the program, advocate for resources such as funding and personnel, and negotiate with the institution for changes beneficial to physics teacher education.

6 **Modest time to engage** includes summer salary, time release, or other support. **Significant time to engage** includes course load modifications, PTE courses included in teaching load, or inclusion of PTE activities in regular duties.

7 The **PTE program team** consists of the program leaders plus other personnel who are responsible for the daily operation of the PTE program.

8 **Modest recognitions** include a thank-you letter, a notice in the departmental newsletter, or broad recognition for educational activities but not specific recognition for PTE.

9 **Awards** may be institutional or external, as long as the nomination is initiated locally (e.g., within the department or institution).

10 **Engaged staff** include non-faculty administrative or other staff who support the program, including Teachers in Residence. Staff may include those funded on external grants.

11 **Institutional funding** can include the portion of site leaders' salaries dedicated to PTE (beyond their normal duties), recruitment activities, Learning Assistant programs, scholarships, a Teacher in Residence, curricular design or reform, Teacher Advisory Groups, or other resources supporting PTE. Except in rare cases, do NOT count the portion of site leaders' or team members' salaries that can be considered part of normal duties (even if they serve physics teacher candidates) such as physics faculty teaching an introductory physics course or advising majors or education faculty teaching a science methods course).

12 **Operational funding** can be internal or external funding and is the specifically dedicated funding required for the program to run successfully (as defined by the program leader), such as funding for a Teacher in Residence or Learning Assistance program. Except in rare cases, faculty salary would not be included, as this does not require dedication of PTE-focused funding.

Standard 2 Leadership and Collaboration

The program has an effective leadership team, including effective collaboration between physics and education.

2A: Program Team Members

The program consists of a team[1,2] whose members enable effective leadership.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
2A-1 PTE program leaders[1] PREVALENT	☐	☐ Program leaders include at least one faculty member.	☐ Program leaders include two faculty members.	☐ Program leaders include three or more faculty members.
2A-2 PTE program team[2] PREVALENT	☐	☐ Team consists of one person in addition to the leader(s).	☐ Team consists of two people in addition to the leader(s).	☐ Team consists of at least two people in addition to the leader(s), at least one of whom is a faculty member.
2A-3 Teacher in Residence (TIR)[3] PREVALENT	☐	☐ There is a part-time physics TIR, or there is a science TIR (at any FTE).	☐ There is one FTE physics TIR.	☐ There is more than one FTE physics TIR.
2A-4 Teacher Advisory Group (TAG)[4]	☐	☐ There is a science TAG.	☐ There is a physics TAG (significant physics teacher membership).	☐ There is a physics TAG that is readily available for consultation by the PTE team.

2B: Program Team Attributes

The PTE program consists of a team[1,2] whose expertise, identity, and activities strengthen the program.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
2B-1 Common vision among the PTE program team[1,2] PREVALENT	☐	☐ The team is not hampered by fundamental disagreements about PTE.	☐ The team shares a common vision for excellence in PTE.	☐ The team's common vision for PTE is explicitly stated (e.g., in a mission statement for the program).
2B-2 Positional power PREVALENT	☐	☐ One member of the team is tenured.	☐ One member of the team holds positional power in the department (e.g., chair, undergraduate chair).	☐ The team has at least one member with positional power and at least one other tenured member.
2B-3 Disciplinary expertise PREVALENT	☐	☐ The team includes a member with expertise in physics and a member with expertise in education.	☐ The team includes a member with expertise in physics education.	☐ The team includes multiple members with expertise in physics education, some with primarily physics expertise and some with primarily education expertise.
2B-4 Personal motivation to improve PTE PREVALENT	☐	☐ One team member is moderately motivated to improve PTE.	☐ One team member is strongly motivated to improve PTE.	☐ Multiple team members are motivated to improve PTE.
2B-5 Integration of Teacher in Residence (TIR) PREVALENT	☐	☐ The TIR interacts frequently with teacher candidates.	☐ The TIR interacts with teacher candidates in more than one venue and engages in at least one other recommended TIR activity.[5]	☐ The TIR is deeply integrated in the program, intersecting with teacher candidates and faculty in multiple settings, and engages in at least two other recommended TIR activities.[5]

Continued

Standard 2 Leadership and Collaboration

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
2B-6 K–12 school engagement PREVALENT	☐	☐ At least one member of the team has K–12 experience.	☐ At least one member of the team is regularly engaged with local schools or school districts.	☐ Multiple members of the team are regularly engaged with local schools or school districts.
2B-7 Physics Education Research (PER) expertise PREVALENT	☐	☐ Team has members that are somewhat familiar with PER.	☐ Team members are very familiar with and use PER practices in their instruction.	☐ Team members are active in the PER community through regular journal reading or conference attendance.
2B-8 Professional engagement in PTE PREVALENT	☐	☐ At least one team member is a member of PhysTEC or similar STEM teacher education organization.	☐ At least one team member regularly attends PhysTEC or similar STEM teacher education conference.	☐ At least one team member has led a session at PhysTEC or similar STEM teacher education organization.
2B-9 Reputation of PTE program team	☐	☐ At least one team member has successfully created change at some level in their institution.	☐ At least one team member has successfully created or substantially modified a new program at their institution.	☐ At least one team member is recognized at their institution as an opinion leader and has a record of creating institutional change.

2C: Program Collaboration

The program includes effective collaboration between the academic unit housing the physics teacher education program (such as physics) and other academic units that control teacher certification (such as education).

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
2C-1 Communication across units on PTE program elements[6] PREVALENT	☐	☐ There are occasional interactions between units on PTE program elements.	☐ There are as-needed meetings or presentations between units on PTE program elements.	☐ There are regular meetings between units to address any issues related to PTE program elements, and all related units participate in program accreditation activities.
2C-2 Negotiated roles between units PREVALENT	☐	☐ The different academic units involved in PTE do not hinder one another's efforts.	☐ Regular practices have been established that guide interactions with other academic units regarding the PTE program.	☐ There is a functional negotiated agreement among the different academic units involved in PTE, including dean-level involvement.
2C-3 Boundary crossers[7] PREVALENT	☐	☐ One part-time team member is a boundary crosser.	☐ One full-time team member is a boundary crosser.	☐ More than one full-time team member is a boundary crosser.
2C-4 Collaboration with PTE mentor[8] **on student teacher placement** PREVALENT	☐	☐ The primary PTE mentor is aware of where PTE candidates are placed.	☐ The primary PTE mentor's feedback is considered during PTE candidate placement.	☐ The primary PTE mentor significantly influences PTE candidate placement.
2C-5 Departmental representation	☐	☐ The PTE team includes faculty in physics or education, with informal contacts in the other department.	☐ The PTE team includes faculty in both physics and education departments.	☐ PTE *program leaders* include faculty in both physics and education departments.

Continued

Standard 2 Leadership and Collaboration

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
2C-6 **Curriculum development between units**	☐	☐ Physics and education are independently involved in curriculum development for PTE.	☐ There are regular meetings between disciplinary and education faculty to discuss PTE curriculum.	☐ Mutual collaboration between physics and education has resulted in a cohesive curriculum, which includes physics content relevancy in essentially all licensure courses.
2C-7 **Collaboration on student advising**	☐	☐ There are informal connections between faculty in physics and education to address student advising questions.	☐ There are regular cross-department meetings to discuss student progress.	☐ There are formal cross-departmental structures to provide discipline-specific advising to physics teacher candidates.
2C-8 **Cohesiveness of student experience**	☐	☐ Students view the physics degree and licensure requirements as two separate programs that are designed to be taken together.	☐ Students view the physics degree and licensure requirements as a single program, but with different expectations and philosophies within each unit.	☐ Students view the physics degree and licensure requirements as a single program with one set of requirements and consistent expectations and philosophies.

1 **PTE program leaders** (also called champions) are those faculty members (tenure or non-tenure track) or administrators in physics or science education (or similar unit responsible specifically for PTE) who spearhead the program, advocate for resources such as funding and personnel, and negotiate with the institution for changes beneficial to physics teacher education.

2 The **PTE program team** consists of the faculty leaders and other personnel who are responsible for the daily operation of the PTE program.

3 A **Teacher in Residence** (TIR) is a person with exemplary understanding of teaching and experience teaching in K–12 schools who functions as an essential colleague to the PTE program. A science TIR has a strong science background and K–12 science teaching experience. A physics TIR has a strong physics background and K–12 physics teaching experience.

4 A **Teacher Advisory Group** (TAG) is a group of local physics teachers that meet regularly with the PTE team to help improve pre-service teacher education and network with teacher candidates.

5 **TIR recommended activities** include: Recruit candidates, work with LA programs, mentor teacher candidates, partner with local teachers, organize TAG meetings, solicit feedback from program participants and graduates, hold regular meetings with faculty leaders, teach or co-teach science methods courses, organize and mentor candidates in field experiences, develop assessment plans for the program, observe and mentor recent graduates, and more (see for example Plisch et al., *The PhysTEC Teacher in Residence*, in C. Sandifer and E. Brewe, *Recruiting and Educating Future Physics Teachers*, American Physical Society, 2015).

6 **PTE program elements** could include students, curriculum, placement, instructor assignments, or advising.

7 **Boundary crossers** are people who have activities in both the academic unit housing the physics teacher education program (e.g., physics, education) and another unit involved with physics teacher education, such as joint appointment, co-teaching, research collaboration, or significant committee service.

8 A **PTE mentor** is a faculty member who specializes in physics teacher education, a TIR, or a local teacher who is able to provide mentoring in careers, skills, and teaching development (not just academic advising).

Standard 3 Recruitment

The program recruits many physics teacher candidates by taking advantage of local opportunities and offering attractive options for participation.

3A: Recruitment Opportunities

The program has access to a pool of potential teacher candidates.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
3A-1 **Physics majors**[1] PREVALENT	☐	☐ The number of physics majors is in 2nd national quartile (3–4/year B.S. programs; 8–13/year PhD programs).	☐ The number of physics majors is in 3rd national quartile (5–8/year B.S.; 14–24/year PhD).	☐ The number of physics majors is in 4th national quartile (9+/year B.S.; 25+/year PhD).
3A-2 **Physics-aligned majors**[2] PREVALENT	☐	☐ There is a pool of physics-aligned majors that is equal to the number of physics majors.	☐ There is a pool of physics-aligned majors that is two to four times the number of physics majors.	☐ There is a pool of physics-aligned majors that is at least five times the number of physics majors.
3A-3 **Recruitment network**	☐	☐ At least one physics faculty actively refers interested students to the PTE program.	☐ Essentially all physics faculty actively refer interested students to the PTE program.	☐ In addition to physics, one to two other units or programs actively refer interested students to the PTE program.
3A-4 **Program identity and reputation**	☐	☐ The program has a name.	☐ The program has moderate identity and reputation (e.g., brochures, logo, local knowledge of the program).	☐ The program has strong identity and reputation (e.g., developed branding, website, regional or national reputation).

3B: Recruitment Activities

The program actively recruits physics teacher candidates.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
3B-1 **Physics teaching advisor** PREVALENT	☐	☐ At least one person in physics can share a viable path to earning licensure.	☐ One person in physics can share in detail the options for becoming a physics teacher.	☐ Two or more people in physics can share in detail the options for becoming a physics teacher.
3B-2 **Physics teaching ambassador** PREVALENT	☐	☐ Potential PTE candidates are exposed to a positive ambassador for science teaching professions.	☐ Potential PTE candidates are exposed to a positive ambassador for the physics teaching profession.	☐ Potential PTE candidates are exposed to a positive ambassador for the physics teaching profession who has K–12 teaching experience.
3B-3 **Accurate information about career benefits**[3] **of teaching** PREVALENT	☐	☐ The PTE program shares accurate information about financial compensation for teachers in the U.S.	☐ The PTE program shares accurate information about financial compensation for teachers in the U.S., as well as at least two less commonly known advantages of the profession.	☐ The PTE program shares accurate information about financial compensation for teachers, including detail for local school districts, as well as at least two less commonly known advantages of the position.
3B-4 **Program promotion**[4]	☐	☐ There is minimal program promotion (1–2 practices).	☐ There is modest program promotion (3–4 practices).	☐ There is substantial program promotion (5+ practices).
3B-5 **Physics climate toward teaching as a career**	☐	☐ Physics faculty discuss teaching as a career as a viable option for physics students.	☐ Teaching careers are discussed within physics as a normative career choice (e.g., on equal weight with academic or industrial careers).	☐ Teaching as a career is widely celebrated in the department (e.g., through awards, recognition, or positive enthusiasm).

Continued

1 **Numbers of physics majors** can be determined using data at https://www.aps.org/programs/education/statistics/compare.cfm.

2 **Physics-aligned majors** are majors with enough physics content knowledge to constitute a minor in physics (e.g. astronomy, mechanical engineering, electrical engineering, etc.). It's best to evaluate according to the topics covered in coursework for each major.

3 **Career benefits** include the following: (1) **Financial benefits**, such as accurate salary information, desirable retirement benefits, student loan forgiveness programs, scholarships, and opportunities for supplementary income. Many of these benefits are typically underestimated (including salary). (2) **Other advantages**, which are less commonly known, such as high intellectual challenge, high overall job satisfaction, opportunities for ongoing scientific professional development, easy job placement, and geographic mobility due to high demand for teachers. These advantages are greater in the teaching profession than in other STEM professional fields. See https://www.aps.org/units/fed/newsletters/fall2017/survey.cfm for more information.

Standard 3 Recruitment

3C: Early Teaching Experiences for Recruiting Teacher Candidates

Early teaching experiences[5] give first- or second-year students a taste of the rewards and challenges of teaching.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
3C-1 Attractiveness of early teaching experiences[5] PREVALENT	☐	☐ Early teaching experiences are somewhat attractive to physics students (e.g., some physics content but includes cost or extra time to participate).	☐ Early teaching experiences are attractive to physics students (e.g., high physics content, time-efficient, free, or course credit).	☐ Early teaching experiences are very attractive to physics students (e.g., high physics content, paid, or other incentives to participate).
3C-2 Exposure to intellectual challenge of teaching PREVALENT	☐	☐ Students participating in early teaching experiences receive informal mentorship in teaching.	☐ Students participating in early teaching experiences learn about teaching as a rigorous intellectual endeavor.	☐ Students participating in early teaching experiences are exposed to physics education research and/or the scholarship of teaching.
3C-3 Availability of early teaching experiences[5]	☐	☐ Early teaching experiences accommodate the number of physics students who typically enter the certification program.	☐ Early teaching experiences accommodate at least twice the number of physics students who enter the certification program.	☐ Early teaching experiences can accommodate several times the number of physics students who enter the certification program.
3C-4 Recruitment within early teaching experiences[5]	☐	☐ Students participating in early teaching experiences are informed at least once about the PTE program and opportunities in the teaching profession.	☐ Students participating in early teaching experiences are informed about the PTE program and encouraged, as a group, to consider teaching as a career.	☐ Students participating in early teaching experiences are individually encouraged and assisted in taking the next steps toward a teaching career.
3C-5 Exposure to K–12 teaching environments	☐	☐ Early teaching experiences have some exposure to 4th–12th grade teaching environments or students.	☐ Early teaching experiences occur primarily in 4th–12th grade teaching environments or students.	☐ Early teaching experiences occur in 4th–12th grade teaching environments or students, with a physics or physical science focus.

3D: Streamlined and Accessible Program Options

The teacher education program provides a variety of options for physics and related majors to complete the program without unduly extending their undergraduate career or taking on financial burdens.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
3D-1 Streamlined undergraduate teaching track in physics PREVALENT	☐	☐ The physics program allows some teaching credits to count toward physics degree requirement (e.g., electives or humanities requirements).	☐ The physics program offers a physics teaching minor that leads to certification.	☐ The physics program offers a teaching track or concentration that is well designed and streamlined to integrate with certification requirements.
3D-2 Time to undergraduate degree plus certification[6]	☐	☐ A physics major will require five years or less to complete the program.	☐ A physics major will likely require five years or less to complete the program if they start as a junior.	☐ Most physics majors can complete the program within their four-year degree if they start as a junior.
3D-3 Post-baccalaureate certification[6]	☐	☐ There is a post-baccalaureate option that will take four semesters to complete.	☐ There is a post-baccalaureate option that will take one year to complete.	☐ There is a post-baccalaureate option that takes one year or less to complete, and there is a part-time coursework option.
3D-4 Certification credits count toward master's degree	☐	☐ Six or more post-baccalaureate credits count toward a master's degree.	☐ 15 or more post-baccalaureate credits count toward a master's degree.	☐ Compact (30 credit) master's degree available to students upon completion of certification.
3D-5 Financial support for physics teacher candidates	☐	☐ Substantial financial support (at least half the cost of attendance) is made available to 1–2 PTE candidates, OR several smaller financial support options are available to many students.	☐ Substantial financial support is made available to >25% of the PTE candidates.	☐ Substantial financial support is made available to >50% of the PTE candidates.

4 **Program promotion** may include marketing of the program itself OR marketing of early teaching experiences that primarily feed into the program (such as an LA program from which there is significant recruitment) in a way that reaches the target audience of potential *physics* teachers. Marketing practices may include announcements in introductory courses, announcements at first-year student orientation, outreach events, a table at career fairs, advertising materials (flyers, brochures, postcards, promotional products, bus advertisements), letters to students (incoming students or continuing students), and announcements (in campus newsletters, email lists, etc.). Any one of these counts as a practice.

5 **Early teaching experiences** are those teaching experiences intended to give first- and second-year students experience with teaching, such as sustained tutoring, sustained outreach, Learning Assistant opportunities, and UTeach Step 1 or other entry-level courses, among other possibilities. Experiences intended to develop the teaching practice (such as student teaching) are documented elsewhere (see Standard 4, Components 4C and 4D).

6 **Undergraduate or post-baccalaureate certification:** If the program does not include one of these options, leave that item blank.

Standard 4

Knowledge and Skills for Teaching Physics

The program ensures that teacher candidates are well prepared to teach physics effectively.

4A: Physics Content Knowledge

The program ensures that teacher candidates have strong physics knowledge.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
4A-1 **Physics degree for physics teacher candidates**[1] PREVALENT	☐	☐ Most physics teacher candidates complete a physics minor or equivalent, but it is not required.	☐ A physics minor or equivalent is required for physics teacher candidates.	☐ Essentially all physics teacher candidates complete a physics major or equivalent (which may or may not be required).
4A-2 **Introductory course pedagogy**	☐	☐ A minority of majors' introductory physics course experiences are with research-based teaching methods.	☐ At least half of majors' introductory physics course experiences are with research-based teaching methods.	☐ Almost all of majors' introductory physics course experiences are with research-based teaching methods.
4A-3 **Student research for teacher candidates**	☐	☐ There is an optional research experience available to teacher candidates.	☐ At least half of teacher candidates participate in a research experience that culminates in a presentation, poster, or paper.	☐ At least half of teacher candidates participate in a research experience that culminates in a presentation, poster, or paper and connects research with educational practice.

4B: Pedagogy Courses and Curriculum

The program ensures that teacher candidates have strong knowledge of physics pedagogy.[2]

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
4B-1 **Physics pedagogy**[2] **credits**	☐	☐ At least half of physics teacher candidates take 1–3 credits of physics pedagogy.	☐ Almost all physics teacher candidates take 3–4 credits of physics pedagogy.	☐ Almost all physics teacher candidates take five or more credits of physics pedagogy.
4B-2 **Scientific practices credits**[3]	☐	☐ Scientific practices account for 1–2 credits within the curriculum.	☐ Scientific practices account for 3–5 credits within the curriculum.	☐ Scientific practices account for six or more credits within the curriculum.
4B-3 **Science pedagogy course instruction**	☐	☐ Most courses teaching science pedagogy are traditionally taught but teach evidence-based methods.	☐ Most courses teaching science pedagogy are evidence-based courses that teach evidence-based methods.	☐ All courses teaching science pedagogy are evidence-based courses that teach evidence-based methods.
4B-4 **Science methods**[4] **instructor expertise**	☐	☐ Instructor of science methods courses has physics teaching experience.	☐ Instructor of science methods courses has 7th–12th grade physics classroom experience.	☐ Instructor of science methods courses has 7th–12th grade physics classroom experience and more than three years of experience teaching methods.
4B-5 **Disciplinary context of certification coursework**	☐	☐ Some of the required certification coursework is taught in the context of teaching science and/or physics.	☐ Most of the required certification coursework is taught in the context of teaching science and/or physics.	☐ Essentially all of the required certification coursework and field experiences are taught in the context of teaching science and/or physics.
4B-6 **Physics microteaching experiences**[5]	☐	☐ At least half the physics teacher candidates participate in physics microteaching with peers.	☐ Essentially all physics teacher candidates participate in physics microteaching with peers.	☐ Essentially all physics teacher candidates deliver physics microteaching lessons to peers at least twice.
4B-7 **Teaching/Learning Assistant (TA/LA) participation**[6]	☐	☐ There are physics TA/LA opportunities, and some physics teacher candidates participate.	☐ At least half of the physics teacher candidates are physics TAs/LAs at some point.	☐ Essentially all physics teacher candidates are physics TAs/LAs at some point.

Continued

Standard 4 Knowledge and Skills for Teaching Physics

4C: Field Experiences in Secondary Physics Teaching

The program provides teacher candidates with high-quality field experiences[7] to put education coursework into practice in a school setting.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
4C-1 Number of cooperating physics teachers[8] for field experiences[7] PREVALENT	☐	☐ Program has access to a minimally sufficient number of cooperating physics teachers for field placements.	☐ Program has access to a sufficient number of cooperating physics teachers for field placements.	☐ Program has access to more than a sufficient number of cooperating physics teachers for field placements.
4C-2 Quality of field experiences[7] PREVALENT	☐	☐ Candidates have a physics or physical science field experience.	☐ Candidates have a physics or physical science field experience accompanied by a university course.	☐ Candidates have a physics or physical science field experience accompanied by a university course and teach a minimum of five lessons on their own.
4C-3 Quality of field experience classrooms PREVALENT	☐	☐ Some field experience learning environments use some evidence-based teaching practices.	☐ Some field experience learning environments primarily use evidence-based teaching practices.	☐ Essentially all field experience learning environments primarily use evidence-based teaching practices.
4C-4 Experience with different populations and environments	☐	☐ Candidates' field experiences *(including student teaching)* are with at least two different teachers.	☐ Candidates' field experiences *(including student teaching)* are with at least two different teachers and two different populations (e.g., cultural backgrounds or socioeconomic status).	☐ Candidates' field experiences *(including student teaching)* are with at least two different teachers, two different populations, and two widely spaced grade levels.

4D: Student Teaching

The program provides teacher candidates with high-quality student teaching[9] experiences in physics classrooms.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
4D-1 University supervisor[10] collaboration with PTE team PREVALENT	☐	☐ The university supervisor consults informally with the PTE leadership team to evaluate and support candidates.	☐ The university supervisor officially collaborates with the PTE team to evaluate and support candidates.	☐ The university supervisor is a member of the PTE team.
4D-2 University supervisor[10] experience PREVALENT	☐	☐ The university supervisor has experience teaching physics.	☐ The university supervisor has experience teaching physics and knowledge of evidence-based teaching practices and K–12 teaching environments.	☐ The university supervisor has extensive experience teaching physics, demonstrated experience using evidence-based teaching practices, rich knowledge of K–12 teaching environments, and experience mentoring adults.
4D-3 Quality of cooperating teachers[11] for student teaching PREVALENT	☐	☐ Some cooperating teachers for student teaching have more than three years of physics teaching experience.	☐ Essentially all cooperating teachers for student teaching have more than three years of physics teaching experience.	☐ At least half of cooperating teachers for student teaching are excellent quality (i.e., teach physics, provide quality mentoring, and demonstrate above-average student learning).

Continued

Standard 4 Knowledge and Skills for Teaching Physics

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
4D-4 Number of quality cooperating teachers[11] for student teaching	☐	☐ Program has access to a minimally sufficient number of cooperating teachers.	☐ Program has access to a minimally sufficient number of cooperating teachers, most of whom meet the "benchmark" level of quality (4D-3).	☐ Program has access to a sufficient number of cooperating teachers, all of whom meet the "benchmark" level of quality (4D-3).
4D-5 Quality of student teaching learning environments	☐	☐ Some student teaching classrooms use some evidence-based teaching practices.	☐ Some student teaching classrooms primarily use evidence-based teaching practices.	☐ Essentially all student teaching classrooms primarily use evidence-based teaching practices.

1 **Physics degree** is a physics major or minor or its equivalent. Physics minor equivalent is defined at www.phystec.org/webdocs/physicsMinor.cfm. A **physics teacher candidate** is a student who has committed to completing a program of physics teacher education.

2 **Physics pedagogy credits** are earned through either (1) completing a *standalone* course devoted to physics teaching and learning, in which case the number of physics pedagogy credits is the same as the number of course credits, or (2) completing a course that has a *component* about physics teaching and learning (such as a science methods course; a guided inquiry physics course, like Physics by Inquiry; an outreach course; or an experiential learning opportunity for teacher candidates, such as a Teaching/Learning Assistantship), in which case the number of physics pedagogy credits is determined by the fraction of time spent on physics pedagogy. For example, if one-third of the course is physics and it is a three-credit course, then physics pedagogy accounts for one credit.

3 **Scientific practices** are an element of the Next Generation Science Standards (NGSS) and include, but are not limited to, asking questions and defining problems; analyzing and interpreting data; and engaging in argument from evidence. See ngss.nsta.org/PracticesFull.aspx for the full list.

4 A **science methods course** is a standalone course exploring techniques in science instruction, taught in the School of Education.

5 **Microteaching experiences** are short lessons (20 minutes or less) delivered to peers, usually followed by reflection and feedback from peers (see E. Etkina, *Phys. Rev. Spec. Top: Phys. Ed. Rsrch.*, 7, 020110, 2010).

6 **Teaching/Learning Assistantships** (TA/LA) are positions in physics (or physics-aligned) departments in which undergraduates are trained to work with faculty as instructional assistants to make courses more interactive or to support interactive engagement in already reformed courses.

7 A **field experience** is an in-classroom K–12 teaching experience for teacher candidates, preferably in a physics or physical-science classroom with an on-campus course component. The goal of a field experience is to put education coursework into practice in a school setting by teaching (or helping to teach) a pre-college class. Observation of K–12 classrooms should not be counted toward this item. College-level teaching experiences (including most LA programs) and student teaching should also not be counted toward this item, as they appear in Standard 3 (Recruitment).

8 A **cooperating teacher for field experiences** is a certified teacher (preferably a physics teacher) who hosts and supervises students during field experiences.

9 **Student teaching** is a capstone field experience in which a teacher candidate teaches in a K–12 setting with full control of multiple classes for at least a semester, fulfilling licensure requirements. The student teaching experience is jointly supervised by the "cooperating teacher" at the K–12 school and the "university supervisor" at the university.

10 A **university supervisor** is a member of the university faculty with expertise in teacher education who is the instructor of record for the student teaching experience, which includes observing and supporting teacher candidates during student teaching. Observation includes observing a full lesson and must include written feedback.

11 A **cooperating teacher for student teaching** is a certified teacher who hosts and supervises student teaching experiences at a school. Because they provide significant mentorship, cooperating teachers should share the PTE team's vision of teaching and learning and have demonstrated mentorship skills (e.g., observing, providing feedback, holding professional conversations, working collaboratively) or receive mentorship training, and they should demonstrate above-average student learning. A "master teacher" designation does not suffice.

Standard 5 Mentoring and Professional Support

The program provides mentoring and induction to support progress towards degree, certification, and retention in the profession.

5A: Mentoring and Support Toward a Physics Degree

The physics program provides structures to help teacher candidates persist and thrive in their progress toward a physics degree.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
5A-1 Student community in physics PREVALENT	☐	☐ There are one or two community-building activities each year (e.g., welcome picnics).	☐ There is an active Society of Physics Students (SPS) chapter or a student lounge.	☐ There is an active SPS chapter and a student lounge.
5A-2 Student advising and career mentoring[1] in physics	☐	☐ Advising provides students with consistent and accurate information about degree options.	☐ Advising provides a clear roadmap of courses to accomplish different career goals, and majors are consistently mentored regarding career options.	☐ Advising supports students in tailoring academic programs to their career interests, and majors are consistently mentored regarding career options.

5B: Mentoring and Support Toward Becoming a Physics Teacher

The program helps teacher candidates persist and thrive in their progress toward becoming physics teachers.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level
5B-1 Advising[2] of physics teacher candidates PREVALENT	☐	☐ Teacher candidates receive academic advising from an advisor knowledgeable about PTE.	☐ Teacher candidates receive academic advising from an advisor who provides a clear roadmap of courses to complete physics and PTE requirements as efficiently as possible.	☐ Teacher candidates receive academic advising from an advisor who is able to navigate the PTE requirements, who is knowledgeable about scholarships and external opportunities, and who can provide creative solutions for completion of requirements.
5B-2 Mentoring of physics teacher candidates by a PTE mentor[3] PREVALENT	☐	☐ Teacher candidates receive some mentoring from a PTE mentor.	☐ Teacher candidates receive regular mentoring from a PTE mentor with experience in K–12 environments.	☐ Teacher candidates receive regular, sustained, holistic mentoring (including career progress and skills development) from a PTE mentor with experience in K–12 environments.
5B-3 Community of physics/STEM teacher candidates[4]	☐	☐ Physics/STEM teacher candidates do one of these: - collaborate in classes; - attend community-building events; - have a lounge or shared workspace.	☐ Physics/STEM teacher candidates do two of these: - collaborate in classes; - attend community-building events; - have a lounge or shared workspace.	☐ Physics/STEM teacher candidates collaborate in classes, attend community-building events, and have a lounge or shared workspace.
5B-4 Community with in-service teachers	☐	☐ Some teacher candidates attend campus events with working teachers.	☐ Most teacher candidates attend campus events with working teachers, but such events are occasional.	☐ Many teacher candidates attend campus events with working teachers, and these events are frequent (several times per year).

Continued

Standard 5 Mentoring and Professional Support

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level

5C: In-service Mentoring and Professional Community

The program monitors and supports teacher graduates to retain them in the profession and develop their physics teaching expertise.

	NP	Developing Level	Benchmark Level	Exemplary Level
5C-1 **Alumni community**	☐	☐ The program offers occasional alumni events.	☐ There are meetings of program alumni every year.	☐ There are meetings of program alumni every semester and/or an active online network.
5C-2 **PTE mentor[3] for beginning teachers**	☐	☐ Many alumni receive some mentoring from a PTE mentor.	☐ Many alumni receive regular mentoring from a PTE mentor with experience in K–12 environments.	☐ Many alumni receive regular, sustained, holistic mentoring (including career progress and skills development) from a PTE mentor with experience in K–12 environments.
5C-3 **Professional development for in-service teachers**	☐	☐ Less than 25 hours of professional development are offered per year.	☐ 25–80 hours of professional development are offered per year.	☐ 80+ hours of professional development are offered per year.

1 **Advising** refers to helping students select course sequences and navigate the path towards their degree. **Mentoring** includes physics skill development and support for career progress. **Tailoring academic programs to career interests** includes taking advantage of program flexibilities, removing barriers, and advising about scholarships and external opportunities, including internships and research experiences.

2 **Advising** refers to helping students select course sequences and navigate the path towards licensure.

3 **Mentoring** includes physics teacher skill development and support for career progress (distinct from "advising"). A **PTE mentor** is a faculty member who specializes in physics teacher education, a TIR, or a local teacher who is able to provide mentoring in careers, skills, and teaching development (not just academic advising).

4 **Community of physics/STEM teachers**. In those institutions with insufficient numbers to create a community among *physics* teacher candidates, a community of STEM teacher candidates should be considered for this item.

Standard 6 Program Assessment

The program assesses multiple outcomes, using them for program improvement and to advocate for funding and resources.

	NP	Possible attributes at Developing Level	Possible attributes at Benchmark Level	Possible attributes at Exemplary Level

6A: Program Outcomes

The program is successful at recruiting, graduating, placing, and retaining teacher candidates.

	NP	Developing Level	Benchmark Level	Exemplary Level
6A-1 **Annual graduation from PTE program** PREVALENT	☐	☐ On average, there is at least one graduate from the PTE program per year.	☐ On average, there are 2–3 graduates from the PTE program per year.	☐ On average, there are four or more graduates from the PTE program per year.
6A-2 **Annual recruitment in PTE program** PREVALENT	☐	☐ 1–2 students enter the PTE program per year.	☐ 3–5 students enter the PTE program per year.	☐ Six or more students enter the PTE program per year.
6A-3 **Diversity of physics teacher candidates**	☐	☐ There is some racial/ethnic diversity among physics teacher candidates.	☐ The racial/ethnic diversity of physics teacher candidates matches the national average among physics B.S. degree recipients.	☐ The racial/ethnic diversity of physics teacher candidates exceeds the national average among physics B.S. degree recipients.
6A-4 **Career persistence[1]**	☐	☐ At least 70% of PTE program graduates remain in the profession after five years.	☐ At least 75% of PTE program graduates remain in the profession after five years.	☐ At least 80% of PTE program graduates remain in the profession after five years.

6B: Program Evaluation and Improvement

The program systematically collects and analyzes student- and program-level data to make informed decisions about program development and improvement.

	NP	Developing Level	Benchmark Level	Exemplary Level
6B-1 **Tracking program metrics[2]** PREVALENT	☐	☐ The program systematically tracks graduation rates.	☐ The program systematically tracks graduation and recruitment rates.	☐ The program systematically tracks graduation, recruitment, and persistence rates.
6B-2 **Feedback[3] from stakeholders** PREVALENT	☐	☐ Program feedback is collected from most candidates or alumni.	☐ Program feedback is collected from most candidates *and* alumni.	☐ Program feedback is collected from most teacher candidates, alumni, and at least some employers.
6B-3 **Assessing learning outcomes[4]**	☐	☐ The program assesses at least two candidate learning outcomes.	☐ The program assesses at least three candidate learning outcomes.	☐ The program assesses at least three candidate learning outcomes plus K–12 student outcomes in classrooms of program alumni.
6B-4 **Program improvement from feedback and program data[5]**	☐	☐ The program uses feedback and program data to make occasional improvements.	☐ The program has carefully examined feedback and program data to make substantial improvements at least occasionally.	☐ The program conducts an annual evaluation or otherwise engages in a systematic cycle of continuous improvement.

Continued

Standard 6 Program Assessment

6C: Communication to Stakeholders

The program communicates its successes to key stakeholders to build support for the program.

	NP	Possible attributes at **Developing Level**	Possible attributes at **Benchmark Level**	Possible attributes at **Exemplary Level**
6C-1 **Communication within the university** PREVALENT	☐	☐ The program consistently communicates its assessment data within the program team.	☐ The program consistently communicates about its successes with one or two departments or academic units.	☐ The program consistently communicates about its successes in campus-wide publications or venues.
6C-2 **Communication with university administrators** PREVALENT	☐	☐ Program leaders consistently communicate with department chairs about program successes.	☐ Program leaders consistently communicate with higher administrators about program successes.	☐ Assessment data is strategically used to argue for program stability by addressing administrators' highest priorities (e.g., student recruitment, financial return).
6C-3 **Publicity and advocacy**[6]	☐	☐ Program successes are publicized at the city or county level (e.g., newspaper articles).	☐ Program successes are publicized (at least at the city level) and include data-based evidence of success, OR program leaders engage in state advocacy.	☐ Program successes are publicized based on data, AND the program leaders engage in state advocacy.
6C-4 **Scholarly work**	☐	☐ The program has contributed to scholarly work in teacher education conducted by other researchers.	☐ The program leaders have published a scholarly paper on the program or its outcomes.	☐ The program conducts systematic research investigations to contribute to knowledge in physics teacher education.

1 **Career persistence** is among the PTE program graduates who become teachers.

2 **Tracking program metrics**. If the academic unit housing the program (such as the School of Education) tracks these numbers, this can be considered as program tracking.

3 **Feedback** may be collected through exit interviews, surveys, and so on.

4 **Learning outcomes** for teacher candidates include grades, DFW rates, learning gains from concept inventories, Praxis II scores, and measures of pedagogical skills (e.g., Reformed Teaching Observation Protocol, UTeach Observation Protocol).

5 **Program data** include program metrics, learning outcomes, Physics Teacher Education Program Analysis (PTEPA) Rubric scores, or other evaluative measures.

6 **Advocacy** includes advocating for changes to state policy that could benefit physics teachers (e.g., serving on a state committee or issuing a policy brief).

APPENDIX 2

Resources for Using the PTEPA Rubric

This section includes resources (worksheets and handouts) for completing the Physics Teacher Education Program Analysis (PTEPA) Rubric and for using the results to improve your program.

IN THIS APPENDIX

(A2-1) PTEPA Party Handout. This handout describes various group processes for completing the PTEPA Rubric and interpreting results and may be used to engage your team in the activity.

(A2-2) Informational Questions. A list of stakeholders whom you may need to consult for completing the PTEPA Rubric, along with information-gathering questions for each.

(A2-3) Importance and Synthesis Ratings. Rating scales and a table that allow you to rate the importance of PTEPA Rubric elements for your program and interpret your ratings as a whole.

(A2-4) PTEPA Rubric Narrative Self-study Template. An outline of a document to describe your program's strength and gaps on the PTEPA Rubric, what you have learned, and your plan of action.

(A2-1) PTEPA Party Handout

Use the handout on the following page with your program team and other stakeholders to generate interest in collectively completing the PTEPA Rubric and to guide the format and discussion of that meeting.

"It's a PTEPA Party" was inspired by "You're invited to a Data Party!" posted by Community Solutions at http://communitysolutions.ca/web/wp-content/uploads/2018/02/Data-Parties-5Ws.pdf.

It's a PTEPA Party!

who?

You and your physics teacher education (PTE) program team and other relevant stakeholders.

what?

Work together to complete and discuss the Physics Teacher Education Program Analysis Rubric*, choosing the most descriptive ratings for your program, discussing the meaning of the data, and deciding on next steps.

why?

We can best make sense of data and use it for improvement when we work together and talk it through.

when?

Anytime! You may wish to take advantage of natural times to focus on strategic planning and reflection, such as:

- Program planning
- Preparing annual reports
- Preparing to make a case for program resources
- Preparing a talk or presentation
- Department strategic planning
- Department or college retreats

how?

Below are some possible formats for your group (allow about three hours, including time to come to consensus and clean up your ratings)

Series. A series of shorter meetings (e.g., one standard per meeting).
Retreat. A single longer meeting.
Segmental. Focus on certain sections of the rubric with certain groups.
Individual. Complete the rubric individually and then meet to discuss as a group.
Coached. Invite a PhysTEC evaluator to act as a reflective coach.

so what?

- What is your evidence for your ratings?
- Where do you disagree?
- What other information do you need?
- What have you learned, and what surprises you?
- What response is required?

then what?

Look at your results as a whole and determine your plan for action! Share your data with stakeholders to generate program support.

*See http://phystec.org/thriving.

(A2-2) Informational Questions

Addressing these questions will help you complete the PTEPA Rubric for your physics teacher education (PTE) program. Some of these questions appear in the interactive (Excel) version of the PTEPA Rubric at http://phystec.org/thriving.

STAKEHOLDERS

In many cases, you may need to interview multiple people from outside the physics teacher education (PTE) team to have adequate data to fully complete the rubric. In Table 4, we list the types of people you may wish to consult.

Table 4. PTE program stakeholders.

Stakeholders	Names of people at your program
Dean (or associate dean) of Arts and Sciences	
Dean (or associate dean) of Education	
Physics department chair	
Education department chair	
Physics faculty	
Education faculty	
Advisors in physics or education	
Education staff in charge of licensure	
University Supervisor for student teaching	
Learning Assistant program coordinator	
Other education staff	
Teacher in Residence/Master Teacher	
Teacher candidates	
Program alumni	
Other	

PROGRAM DEFINITIONS AND INFORMATION

This information is particularly useful to complete before filling out the PTEPA Rubric to ensure that you have adequate information and have defined certain elements of the program.

1. What is the name of your PTE program?
2. Approximately what year did your program start?
3. Do you have a website or other documentation?
4. What degree(s) would a teacher candidate receive from your program?
5. What are the licensing/credential options available as a result of a degree in your program? What subjects are students eligible to teach as a result of getting each credential?
6. Does a teacher certified to teach physics in your program need to be able to teach other subjects to be employable in your area?
7. Are there any contextual factors that are important to understand about your program, such as state mandates, teacher salaries, employability of graduates, and so on?
8. Please list the courses that are part of your physics teacher preparation program.
9. List the names of your program's leaders.[1]
10. List the names of others on your program team.[2]
11. Name the unit within which the PTE program resides (e.g., the physics department).
12. Name the unit(s) with which the PTE program collaborates (e.g., the School of Education).

INFORMATION-GATHERING QUESTIONS

These are questions that may be useful for an internal or external program evaluator to use to conduct informational interviews with the above stakeholders.

All stakeholders:

- What do you think makes this program so successful at educating lots of physics teachers?
- Are there any contextual factors that have contributed to this success (such as teacher salaries or local demand for teachers)?
- Are there any specific influences that have contributed to this success, such as PhysTEC, other grants, local or national programs, or other limited time interventions?

Administrators (deans, chairs):

- What is the mission of the university? Do you see this mission as supporting STEM teacher preparation?
- To what degree does the institution prioritize STEM teacher preparation? How is this level of priority demonstrated in practice?
- To what degree does the college prioritize physics teacher preparation? How is this level of priority demonstrated in practice?
- What steps have you taken to ensure the success of STEM or physics teacher preparation programs?
- What financial allocations does the university make that support STEM teacher education? What proportion supports physics teacher preparation?
- In what ways do you support or reward faculty engagement with STEM or physics teacher preparation?
- Which faculty or staff members contribute to PTE?

Education faculty:

- Have you or other faculty here received any financial incentives, rewards, or other recognition for your engagement with PTE (not including tenure and promotion)? Describe.
- Are there clear roles and responsibilities for physics and education faculty with respect to the PTE program? How do the two units collaborate on PTE?

Physics faculty and chair:

- Have you or other faculty here received any financial incentives, rewards, or other recognition for your engagement with PTE (not including tenure and promotion)? Describe.
- What opportunities are there for physics students to engage in research in physics or physics education? How many of them do so either independently or within a course?
- How are undergraduates informed about possible careers open to people with physics degrees?
- Do faculty here encourage students to pursue teaching careers? Who does so?
- If a student wants to be a teacher, who can they go to for advice and support?
- How are undergraduate physics majors advised?

Teacher candidates:

- Who has encouraged you to pursue teaching as a career? Where was this mentioned and how consistently?
- How strictly were the physics course requirements enforced? Do you feel you have deep physics content knowledge?
- Where did you get the pedagogical knowledge you need to be an effective teacher?
- What got you interested in the PTE program?
- What early teaching experiences did you get at the university?
- What opportunities have you had to engage in research as an undergraduate?
- How often do you find yourself in a classroom using predominantly lecture-based teaching during your introductory physics courses?
- How many years do you feel the certification program is adding to your time to degree?
- What financial support have you gotten as a physics teacher candidate?
- What sort of opportunities have you had to engage in a community of teachers (either locally or nationally)?
- How are undergraduate physics majors advised?
- What requests for feedback have you gotten from the program since you graduated?

Alumni:

Ask the questions above for teacher candidates, plus:

- What support have you gotten from the program since you graduated?
- What requests for feedback have you gotten from the program since you graduated?

(A2-3) Importance and Synthesis Ratings

The “importance and synthesis ratings” table below supports subjective reflection on which elements of the PTEPA Rubric are most important for your program and how you would rate your program’s current overall achievement on the rubric.[3] This synthesis of your PTEPA Rubric ratings will support you in interpreting your results, identifying possible next steps and action items, and observing whether your program ratings change over time. We recommend using these ratings in conjunction with the narrative report (below) to provide clear actionable steps to guide program development.

A. IMPORTANCE RATINGS

Which elements of the PTEPA Rubric should you prioritize? Different programs have different priorities, depending on factors such as institutional context and program history. We suggest rating the different standards and components on the PTEPA Rubric as to their importance for your program now and three years in the future as “lower,” “medium,” or “high” priority (or on another scale that suits your needs). Completing this rating can help you to continue to use the PTEPA Rubric over time to prioritize and emphasize your efforts in certain areas.

B. SYNTHESIS RATINGS

How can you interpret your PTEPA Rubric ratings as a whole? As discussed in Chapter 6, it is not appropriate to expect your program to rate Exemplary (or even Benchmark) on a majority of items, including the Prevalent items. However, you may wish to determine for your own purposes whether you can be satisfied with your program’s rating on different standards and components. Table 5 suggests a rating scale for your program team’s satisfaction with its PTEPA Rubric results.

Table 5. Synthesis rating scale.

Overall rating	Program team’s synthesis rating
Excellent	Program has clear Exemplary practices across this domain with no weaknesses that matter for the program.
Very good	Program has Benchmark to Exemplary practices on virtually all aspects in this standard. A few slight weaknesses that are not critical for the program are acceptable.
Good	Program has reasonably good performance overall with a few slight weaknesses (i.e., Developing or NP), some of which may be important to the program.
Fair	Program has modest performance, including some serious weaknesses (i.e., Developing or NP) on a few aspects that are important for this program.
Poor	There is clear evidence of unsatisfactory program functioning, including weaknesses on some serious aspects.

C. ANNUAL IMPORTANCE AND SYNTHESIS TABLE

Complete Table 6 (next page), preferably on an annual basis, to reflect the importance and overall synthesis ratings of each element of the rubric.

Table 6. PTEPA Rubric importance and synthesis ratings.

Standard or Component		Importance *Lower – Medium – High*		Synthesis Rating *Poor – Fair – Good – Very Good – Excellent*		
		Now	In 3 years	Year 1	Year 2	Year 3
1	**INSTITUTIONAL COMMITMENT**					
1A	Institutional Climate and Support					
1B	Reward Structure					
1C	Resources					
2	**LEADERSHIP AND COLLABORATION**					
2A	Program Team Members					
2B	Program Team Attributes					
2C	Program Collaboration					
3	**RECRUITMENT**					
3A	Recruitment Opportunities					
3B	Recruitment Activities					
3C	Early Teaching Experiences for Recruiting Teacher Candidates					
3D	Streamlined and Accessible Program Options					
4	**KNOWLEDGE AND SKILLS FOR TEACHING PHYSICS**					
4A	Physics Content Knowledge					
4B	Pedagogy Courses and Curriculum					
4C	Field Experiences in Secondary Physics Teaching					
4D	Student Teaching					
5	**MENTORING AND PROFESSIONAL SUPPORT**					
5A	Mentoring and Support Toward a Physics Degree					
5B	Mentoring and Support Toward Becoming a Physics Teacher					
5C	In-service Mentoring and Professional Community					
6	**PROGRAM ASSESSMENT**					
6A	Program Outcomes					
6B	Program Evaluation and Improvement					
C	Communication to Stakeholders					

(A2-4) PTEPA Rubric Narrative Self-study Template

Even programs that prepare many future physics teachers have room for improvement. Through the process of completing the PTEPA Rubric, you will undoubtedly uncover such areas for your own program. This narrative self-reflection should include detailed observations about your program's specific strengths and weaknesses, a critical reflection on the overall quality of your program, and steps you plan to take in the next three years to grow or improve your program based on the PTEPA Rubric results.

This document will guide you in drafting your narrative self-study (suggested length: approximately 1000 words). Completing the "importance and synthesis ratings" table (Table 6) will be useful preparation for writing this narrative, especially to focus on items and areas that are important for your program. These ratings may be appended to this self-study as further evidence to support your conclusions about your program along with your rubric results.

Part 1: Project information
Name of institution and program:
Names and titles of report authors:
Names and titles of those who substantially contributed to completing the rubric:
Part 2: About your program
Provide a general introduction statement describing your PTE program, teacher certification options, and pertinent institutional characteristics.
Part 3: Written narrative
In a written narrative, address the six standards of the PTEPA Rubric. Make the best use of your space to address strengths and gaps of your program in each area that is relevant for your institutional context (you need not give equal space to each standard). Reference the PTEPA Rubric data in your narrative and include visualizations of your PTEPA Rubric data as appropriate. If you have completed the "importance and synthesis ratings" for the rubric, reference those as appropriate.

Standard 1: Institutional Commitment
Where does your program demonstrate strength in this standard? Where is there room for improvement?
Standard 2: Leadership and Collaboration
Where does your program demonstrate strength in this standard? Where is there room for improvement?
Standard 3: Recruitment
Where does your program demonstrate strength in this standard? Where is there room for improvement?
Standard 4: Knowledge and Skills for Teaching Physics
Where does your program demonstrate strength in this standard? Where is there room for improvement?
Standard 5: Mentoring and Professional Support
Where does your program demonstrate strength in this standard? Where is there room for improvement?
Standard 6: Program Assessment
Where does your program demonstrate strength in this standard? Where is there room for improvement?

The PTEPA Rubric narrative self-study template is inspired by the self-study report from Excellence in Assessment[4] from the National Institute for Learning Outcomes Assessment.

Part 4: Reflection
What were the biggest surprises or revelations for your program team in completing the PTEPA Rubric?
What are your program's biggest strengths? How might these strengths be leveraged for improvement?
Part 5: Plan for action
How are you planning to grow or improve your program as a result of completing the PTEPA Rubric? List at least three concrete steps you will take to accomplish your plans. When will you next complete the PTEPA Rubric?
Part 6: Feedback (optional)
Do you have any recommendations for improvement of the PTEPA Rubric or the process of completing it?

ENDNOTES

1 PTE program leaders (also called champions) are those faculty members (tenure or non-tenure track) or administrators in physics or science education (or similar unit responsible specifically for PTE) who spearhead the program, advocate for resources such as funding and personnel, and negotiate with the institution for changes beneficial to physics teacher education.

2 The PTE program team consists of the faculty leaders and other personnel who are responsible for the daily operation of the PTE program.

3 The importance and generic "synthesis" rating scales were inspired by Oakden, J., Understanding the components of evaluative rubrics and how to combine them (Pragmatica Limited, Wellington, NZ, 2018). Accessed at http://pragmatica.nz/wp-content/uploads/pragmatica-nz/sites/326/Oakden-J.-2018-Components-of-evaluative-rubrics.-Wellington-NZ-Pragmatica-Limited..pdf.

4 See http://www.learningoutcomesassessment.org/eiadesignation.html.

APPENDIX 3

Case Studies of Thriving Programs

Here we describe the eight thriving physics teacher education programs that informed the PTEPA Rubric development and validation.

OVERVIEW OF THRIVING PROGRAMS

As part of validating the PTEPA Rubric, program visits were conducted at the following eight thriving physics teacher education programs. Program visits were commissioned by the Department of Education and Diversity in the American Physical Society and were conducted between January and June of 2017 by Stephanie Chasteen (Chasteen Educational Consulting) and Rachel E. Scherr (Scherr & Associates).

Examples from each program represent the practices at the time of the visit. This is important because many programs have already undergone significant changes since that time.

University of Texas at Austin (UTeach Austin)
A four-year program at a research-intensive university that is the flagship institution of the Texas state system. Students in UTeach earn a STEM degree and obtain their teacher certifications in a specialized program for STEM majors. UTeach Austin is the original UTeach program, which has been replicated at over 40 institutions. *Visit host: Michael Marder.*

University of Colorado Boulder (CU Boulder)
A self-contained, primarily undergraduate, STEM teacher licensure program and UTeach replication program (termed CU Teach) that was also a PhysTEC site, located at a research-intensive university that is the flagship institution of the University of Colorado system. *Visit host: Valerie Otero.*

Brigham Young University
A program at a private religious university (led by a tenured physics faculty member who is also an expert secondary science teacher) in which an undergraduate physics degree is structured to lead to education licensure in physics or physical science. *Visit host: Duane Merrell.*

California Polytechnic University, San Luis Obispo (Cal Poly San Luis Obispo)
A PhysTEC site at a technically focused public university in which physics and physics-aligned majors reach licensure in a one-year post-baccalaureate program in the School of Education and are supported throughout the process by an interdisciplinary STEM center. *Visit host: Chance Hoellwarth.*

Georgia State University
A recently-funded PhysTEC site at an urban-serving university with a highly diverse student population, led by a physics faculty member, in which an undergraduate physics degree is coordinated with education licensure. *Visit host: Brian Thoms.*

Rowan University
A PhysTEC-funded program at a former normal school in which physics majors work toward licensure either through a double major in physics and secondary education or a physics major followed by a master's degree in STEM teaching. *Visit host: Karen Magee-Sauer.*

Rutgers University
A physics-focused master's program housed in the Graduate School of Education, led by an education faculty member with expertise in secondary physics teaching and physics education research. *Visit host: Eugenia Etkina.*

Stony Brook University
A program at a research-intensive public university in which physics majors reach licensure in an 18-month post-baccalaureate program under the umbrella of an interdisciplinary STEM education center. *Visit host: Keith Sheppard.*

In the following text, a number and letter in parentheses, like "(1A)," indicates the component in the PTEPA Rubric that is being referenced.

CASE STUDY

University of Texas at Austin

The University of Texas at Austin is a public research university located in Austin, Texas, and is the flagship institution of the University of Texas system. The total enrollment is 51,000 students.

PROGRAM OVERVIEW

Program Context. Practically speaking, in Texas students must be prepared to teach science content other than physics in order to be employable in the K–12 sector, since all certifications are composite certifications (see below). These composite certifications were created in order to address statewide teacher shortages in STEM, allowing qualified teachers to teach multiple disciplines. Teacher salaries in the state do not offer a great incentive to enter teaching; salaries start at $43,000/year, with a slight increase for master's degree holders.

Certification Options. There is no sole physics certification among the secondary STEM certifications. In the certifications following, the certifications allowing a student to teach physics are indicated with an asterisk. All certification options: Composite Science* (choosing one discipline, such as physics, as the primary field), Math, Physical Science*, Physics/Math*, Engineering/Physical Science/Math, Computer Science, and Computer Science/Math.

The program visit for the PTEPA Rubric occurred in March 2017 and was conducted virtually by Stephanie Chasteen.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this site's program on the PTEPA Rubric. Due to their long history, substantial funding and staff, institutional support, and specialized curriculum, UTeach Austin is rated as exemplary on most areas of the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A The program was created under an initiative of the dean of the College of Science to address new state laws regarding certification. UT Austin is proud of the program, and it would likely be politically unpopular to consider cutting it.

1C UTeach commands significant resources, including seven Master Teachers, high levels of sustained internal and external funding, multiple staff, and a central space. It functions as an academic unit, enabling it to direct its own staff and budget and negotiate commitments at the college level.

Leadership and Collaboration (Standard 2)

2A, 2B The program is led by two faculty directors and two faculty co-directors, some of whom are current or former administrators, with appointments in the Colleges of Education and the Natural Sciences.

2A, 2B The program employs seven Master Teachers, one of whom has expertise in physics, who have stability of employment and coordinate multiple elements of the program.

2B Two of the tenured faculty in program leadership have physics backgrounds, enabling close connection to physics expertise.

2C New STEM-specific courses were developed in collaboration between the College of Natural Sciences and College of Education.

2C The program directors report directly to the deans of the colleges of Education and Natural Sciences, enabling college-level collaboration originating at the dean level.

Recruitment (Standard 3)

3A The program has a long history with a strong identity and reputation.

3B UTeach and STEP 1 are marketed through multiple mechanisms, and students are encouraged to consider teaching careers.

3C A one-credit free course (STEP 1) gives students an early taste of the rewards of teaching.

3D Students can complete a traditional STEM major, with teaching certification, in four years for no additional cost.

Knowledge and Skills for Teaching Physics (Standard 4)

4B Two of the faculty teaching the STEM-broad pedagogy courses have physics backgrounds and thus provide a good connection to physics content within these courses.

4C Students have multiple field experiences; they teach lessons in the public schools throughout the curriculum and have options of education-related outreach and internships.

Mentoring and Professional Support (Standard 5)

5B The program's substantial staff and budget enable individualized mentoring and advising and social events.

5C One Master Teacher runs a significant new-teacher mentoring program, and all teachers receive a care package upon entering the field.

Program Assessment (Standard 6)

6B Program metrics are carefully tracked, including relationships between variables such as ethnicity and program outcomes.

6C Program metrics are communicated regularly to administrators and donors to build support for the program.

Program Structure. The University of Texas at Austin is the original site for the UTeach program, founded in 1997. UTeach Austin is a STEM-broad teacher preparation program, operating as a distinct academic unit at the institution in cooperation between the Colleges of Education and Natural Sciences.

At UTeach Austin, students can earn a teaching certification as part of a four-year undergraduate degree either by selecting the teaching option within one of five STEM disciplines or by completing a traditional disciplinary major with additional coursework to obtain certification. UTeach requires that teacher candidates major in one of the disciplines in which they will be licensed or take equivalent coursework to a major. There is a separate post-baccalaureate program.

In 2006, UTeach established a national UTeach program, and there are currently 45+ replication sites around the country. Among those replication sites, UTeach at the University of Texas is one of the highest producers of physics teachers; they are a consistent member of the 5+ Club,[1] recognizing programs that graduate five or more qualified physics teachers in a year.

Many of their graduates are licensed to teach physics due to composite certification (25+ graduates/year), but only a fraction of those (5+/year) major in physics or in engineering disciplines that contain adequate physics content to count towards 5+ Club membership. More information about UTeach at the University of Texas can be found at PhysTEC's informational page about UT Austin[2] and the UTeach website.[3] Information about the national UTeach replication program and the UTeach Model is at the UTeach Institute site.[4]

NARRATIVE

Institutional Commitment. The UTeach program at the University of Texas at Austin was developed in 1997 under an initiative of the dean of the College of Science to address new state legislation requiring teachers to hold a degree in their subject area. The program continues to be strongly supported at the institutional level (PTEPA Rubric 1A), with continued funding from the College of Natural Sciences and the College of Education (1C).

UT Austin is proud of the program (1A), highlighting it publicly as a success story; it would likely be politically unpopular to consider cutting the program. The program longevity has also generated a strong regional and national reputation and allows program instructors to draw on their numerous local graduates to house field experiences and student teaching. UTeach functions as a separate academic unit, allowing it to command its own staff, budget, and space (including a student lounge specifically for UTeach) and negotiate agreements at the college level (2C). The high level of funding of UTeach (1C) has many benefits, not the least of which is the ability to hire multiple Master Teachers and staff (1C, 2A), allowing UTeach to maintain a more robust program than would be feasible under a solo faculty member.

Leadership. UTeach Austin has a strong leadership team (2A) and is led by two faculty co-directors (one in physics and one in education; 2B, 2C), with several members of the leadership team having substantial positional power (current or former deans) and substantial expertise in physics or physics education research. There is also significant collaboration between the Colleges of Education and Natural Sciences (2C); the program directors report directly to the deans of those colleges.

Coursework. An unusual aspect of UTeach Austin is that Texas certifications are STEM-broad (in an effort to meet a shortage of STEM teachers), and so physics students must be prepared to teach across STEM disciplines. Because new STEM-specific education courses were developed for the program, disciplinary content is embedded across the certification coursework (4B). While there are no physics-specific pedagogy courses, many of the STEM-broad courses include significant physics applications, with physics students working in small groups to apply the lessons to their discipline.

Several people on the program staff have deep expertise in physics and physics education research, enabling infusion of physics-specific pedagogy within these STEM-general courses (4B). Additionally, most physics students also take a Physics by Inquiry course in which inquiry pedagogies are modeled as a new way to understand physics content. These physics-specific supports may account for the relatively high number of physics majors who complete teaching certification. The STEM-broad nature of the program enables a certain economy of scale, since the program serves all future STEM teachers at the institution; at any one time there may be 400–500 students enrolled in the program, of whom 20–30 are physics (or similar) majors.

In order to address the specific teaching needs of STEM teachers, new courses were developed (in close collaboration between the two colleges) rather than simply rebranding existing courses. This resulted in a very STEM-specific curriculum, with STEM pedagogy and content closely intertwined (4B). For example, in lieu of a generic "classroom management" course, students in UTeach take a Classrooms Interactions course, which focuses on interactions between students, teachers, and the content. This pedagogical content knowledge is then supported through field work throughout the curriculum (4C), where students teach lessons in public schools (prior to student teaching), supported by substantial reflection and mentoring (5B).

Additionally, students have the option of a teaching internship, where they are paid a stipend to work with Austin-area nonprofits with an educational focus (4C). Student teaching is coordinated and supervised by two Master Teachers, with access to a large pool of qualified physics teachers (4D). These opportunities provide significant hands-on experience with teaching, helping to renew students' commitment to the profession and ensuring that they are well prepared to teach upon graduation.

Recruiting. A main recruiting mechanism for the program is the Step 1 course; this is a one-credit course that is offered for free (subsidized by UTeach) in which students are given a low-barrier opportunity to explore teaching (3C) through preparing short lessons for elementary students. This course is actively advertised as an introduction to teaching as a profession, and students are often inspired and excited by working with elementary school children. Students within Step 1 are encouraged to continue to Step 2, a similar course working with middle school populations. Step 1 courses and the UTeach program are broadly advertised (3B) through postcards to all incoming students, announcements at summer orientation, letters to continuing students, Google ads, announcements in large STEM courses, and the active UTeach Outreach program and course. A significant recruitment mechanism is also offered by the highly streamlined degree program; students can complete a traditional STEM major as well as earn a teaching certification in four years (3D). This streamlined, low-cost degree is critical to maintaining equity in the program, making teaching certification broadly available to students from diverse backgrounds, including those in under-served communities.

Mentoring. The large staff (including multiple Master Teachers) and funding enable the program to provide a wide variety of individualized mentoring and support structures (5B), including individual UTeach advisors, field experiences and a student organization, food for social events, and a popular formal mentoring program for new teachers (5C), who all receive a starter "care package" with useful supplies. Master Teachers coordinate many of these programmatic elements.

Assessment. UTeach Austin also carefully tracks a wide variety of program metrics (6B), including graduation, recruitment, and persistence data; alumni feedback; and student learning outcomes, and UTeach Austin uses these data to inform the program about possible improvements. The directors are persistent in communicating this assessment data to administrators, donors, and other stakeholders to ensure continued program support (6C).

CASE STUDY

University of Colorado Boulder

The University of Colorado Boulder is a public research university in Boulder, Colorado. Undergraduate student enrollment is about 25,000.

PROGRAM OVERVIEW

Program Context. Teacher candidates must be prepared to teach disciplines other than physics, as certification is composite across science disciplines. Graduates are easily placed into satisfying positions. CU Boulder has a strong culture of science education improvements, including a well-known Physics Education Research program. The School of Education has a national reputation, and CU Boulder is the original home of the Learning Assistant (LA) program. CU Teach program graduates are easily placed in local districts due to the strong local reputation of CU and CU Teach.

Certification Options. Students are licensed in secondary science, which requires a degree in a specific science and courses in the other sciences. The license enables them to teach any science discipline.

The PTEPA Rubric program visit was conducted in person by Stephanie Chasteen in May 2017.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A CU Boulder has a long-standing history of commitment to STEM educational improvements among higher administrators, mostly evidenced by provost support for the Learning Assistant program.

1C CU Teach is supported by several staff who are paid through institutional funding and endowments with some commitments for continuation of that funding.

Leadership and Collaboration (Standard 2)

2A, 2B Physics teacher education is championed by a tenured faculty member with expertise in physics education and a strong reputation as an institutional leader.

2A, 2B CU Teach is supported by a team that has significant physics teaching and PER expertise, including two Master Teachers with physics teaching experience who teach classes, mentor students, and maintain relationships with local teachers.

Recruitment (Standard 3)

3A A large pool of physics, astrophysics, and engineering majors is available.

3B CU Teach is widely promoted (course announcements, letters to freshmen, brochures, bus ads, and the Learning Assistant program), and teaching is visibly celebrated in the Physics Department.

3C Early teaching experiences in Step 1 courses introduce students to the rewards and expertise of teaching in elementary classrooms and expose them to the Master Teachers as positive ambassadors for the teaching profession.

3C Early teaching experiences in the LA program provide an attractive opportunity for students to experience the rewards of teaching, supported by a high-quality pedagogy course.

3C The Teaching and Learning Physics course attracts students to physics teaching.

Knowledge and Skills for Teaching Physics (Standard 4)

4C Candidates engage in multiple field experiences in the Step 1 and Step 2 classes and several classroom practicums before student teaching, resulting in 800 classroom hours by the end of the certification program.

4D The Master Teachers serve as University Supervisors for the student teaching experience, enabling deep mentoring due to the sustained personal relationships between Master Teachers and teacher candidates.

4C, 4D The longevity of the program, sustained efforts (including summer professional development) led by the Master Teachers, and the Teacher Research Team program and the Physics and Everyday Thinking High School Curriculum project (led by Otero) have resulted in a large number of qualified cooperating teachers for field experiences in the area.

Mentoring and Professional Support (Standard 5)

5B CU Teach Master Teachers provide personalized, sustained mentoring for students and work closely with the staff advisor who provides academic advising.

Program Assessment (Standard 6)

6B CU Teach program data is systematically tracked by the School of Education, and the program solicits feedback from students and alumni.

6C The program leader directs original research to contribute to knowledge about physics teacher preparation.

6C CU Teach program data is consistently publicized locally and with administrators to argue for its successes.

Program Structure. CU Boulder is an early PhysTEC site, having received funding in 2004. CU Boulder is also now a replication site for UTeach; CU Teach was established in 2006. CU Teach is a STEM-broad teacher preparation program and is currently housed in the School of Education. CU Teach serves about 100 students at a time with approximately 20–30 graduates each year.

Physics teacher candidates receive a B.S. in physics and take additional coursework in other sciences and in the School of Education to obtain certification, which takes 4–5 years. Both the post-baccalaureate program and the master's plus certification program share many courses but are (on paper) distinct from the undergraduate certification program.

CU Teach is known for producing high-quality teachers, and its graduates are in demand in local school districts. The CU Boulder physics teacher education program became a member of the 5+ Club in 2017. More information about CU Teach can be found on its website,[5] the Colorado PhysTEC site,[6] and PhysTEC's informational page about CU Boulder.[7]

NARRATIVE

Leadership. Physics teacher education at the University of Colorado is supported by an effective leadership team as well as a historically positive climate for STEM teaching improvements. The longtime faculty leader of physics teacher education, Valerie Otero, is a nationally known expert in physics education and PER (2B) and a tenured professor in the School of Education. Otero has been able to effectively advocate for physics teacher education in part due to this expertise and in part due to her local and national recognition for leadership in STEM education (2B), primarily through the Learning Assistant (LA) program that she helped to establish at CU Boulder and internationally and the Physics and Everyday Thinking project. Multiple other faculty support the broader CU Teach program (David Webb, Vicki Hand, Erin Furtak, and Enrique Lopez).

Institutional Commitment. The institution is historically supportive of STEM educational improvements (1A), due in large part to support from the chancellor (a former high school teacher) and engagement from a suite of high-profile scientists focused on teaching, including National Academy member Dick McCray, who founded the LA program,[8] and Carl Wieman, who spearheaded the Science Education Initiative.[9]

Recruitment. CU Boulder has been involved in recruiting future physics teachers for many years, serving as one of the initial PhysTEC sites in 2004 as an interdepartmental collaboration (2C) between Otero and PER physics faculty (Noah Finkelstein and Steven Pollock). The CU Boulder Physics Department is known as a national leader in physics education and provides a supportive crucible for recruiting students to teaching. The Physics Department has a great wealth of LA opportunities across the curriculum (3C), several world-class instructors, and an active PER group, all of which provide a supportive climate for future teachers (3B). Extensively reformed physics courses add to this climate as well as providing excellent physics foundational knowledge (4A) for candidates.

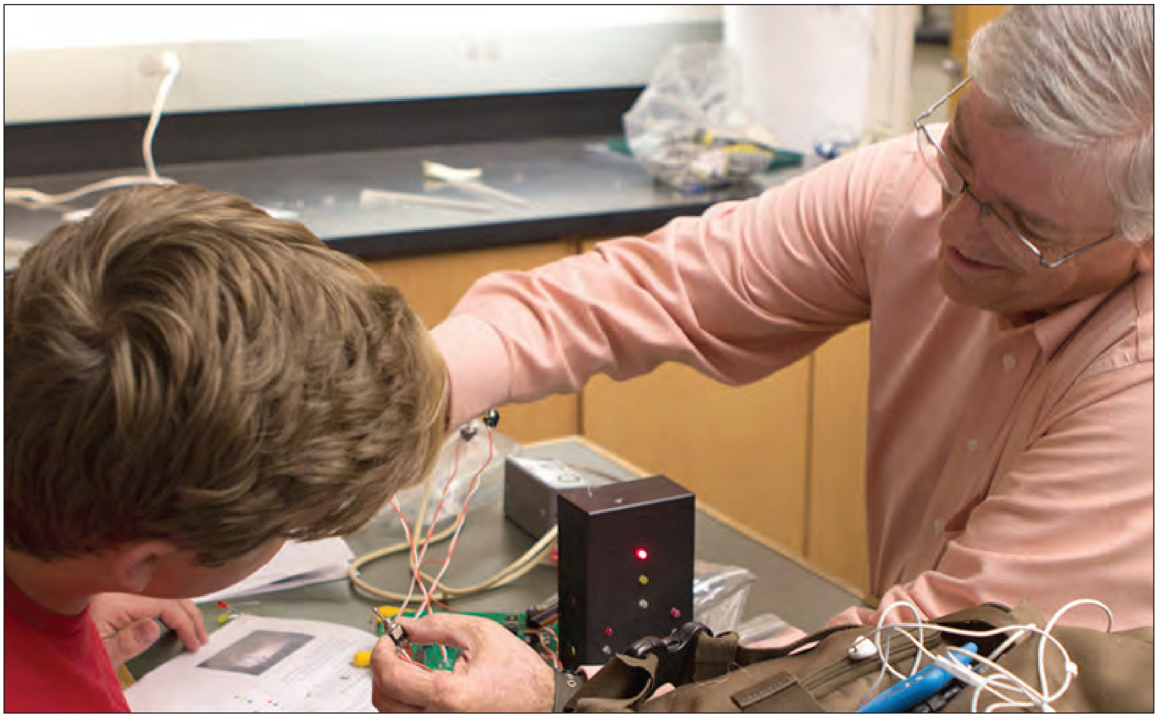
CU Boulder currently conducts physics teacher education as part of CU Teach,[10] a replication of UTeach. Students are recruited into teaching through two early teaching experiences (3C): Step 1 (in elementary classrooms) and Step 2 (in middle school classrooms) are one-credit courses that give students opportunities to practice teaching in an engaging way. Additionally, the LA program at CU Boulder is active and thriving and provides some recruitment into the program (about half of physics teacher candidates are former LAs). Students in STEP courses and the LA program are actively recruited into teaching (3C), and CU Teach is also announced in introductory courses and several other venues (such as LA poster sessions and mailings to freshmen; 3B). Additionally, the pedagogy course (for LAs) and the mentoring associated with Step 1 courses introduce students to the complexity of teaching (3C). Along with the active PER group in physics, this helps physics majors see education as a high-status profession that is worthy of effort.

Master Teachers. Much of CU Teach's success at the time of the PhysTEC program visit hinged on the work of Master Teachers (2A), experienced K–12 teachers with sustained employment with the program (though their employment is renewed on an annual basis). The Master Teachers are deeply integrated with the program (2B) through teaching STEP and methods classes, mentoring students, cultivating relationships with area teachers, and spending substantive time in field experiences observing lessons and giving feedback to students (4C). Thus, teacher candidates experience sustained personalized care and mentoring (5B), as the Master Teachers grow to know teacher candidates individually across their undergraduate careers.

Students in CU Teach are well prepared to teach physics. Students are able to learn physics-specific pedagogy (4B) in several (optional) venues, including Teaching and Learning Physics (taught in physics), Energy and Interactions (using the Physics and Everyday Thinking curriculum), and the LA Experience and corresponding pedagogy course. The program uses several varied field experiences (4C) as well as student teaching (4D), resulting in students having 800 classroom hours by the end of the certification program and strong career preparation. Master Teachers also dedicate time to building relationships with local teachers, which has enabled CU Teach to create a strong local network of cooperating teachers for field placements (4C) and student teaching (4D). This network is bolstered by the Noyce program, which partners teacher candidates and working teachers in Teacher Research Teams (TRTs).

CASE STUDY

Brigham Young University



Brigham Young University (BYU) is a private religious university in Salt Lake City, Utah, which is associated with the Church of Jesus Christ of Latter-Day Saints and has a population of about 30,000 students.

PROGRAM OVERVIEW

Program Context. BYU has a large number of physics majors. The physics teacher education program has been especially active since 2004, when the current faculty leader arrived, and it has produced an extraordinary number of physics teachers, averaging about 15 per year.

Certification Options. The state of Utah offers a secondary education license with endorsements in physics and/or physical science.

The program visit for the PTEPA Rubric occurred in May 2017 and was conducted through phone interviews by Rachel E. Scherr.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A The mission of the university is strongly aligned with teacher education.

1A The College of Arts & Sciences funds teacher professional development, outreach activities, and redesign of classrooms that benefit future physics teachers.

1B The PTE faculty leader is featured in the university's glossy magazine.

1B The PTE faculty leader was recently promoted to full professor based on his PTE activities, in spite of his nontraditional background.

1B The PTE faculty leader recently received a college-level teaching award for his PTE activity.

Leadership and Collaboration (Standard 2)

2A, 2B There is one full-time TIR each year who is on leave from a local school district; the TIR is deeply integrated in the program, teaching courses and mentoring candidates.

2C Formal cross-departmental structures ensure that physics teacher candidates get discipline-specific advising.

2C The PTE program leader influences student teaching placements.

Recruitment (Standard 3)

3A, 3B There are large numbers of physics majors and physics-aligned majors.

3B The PTE program leader is a strongly positive and well-informed ambassador for the physics teaching profession.

3C The physics department offers a physics teaching major incorporating both a physics major and coursework leading to licensure.

Knowledge and Skills for Teaching Physics (Standard 4)

4B Student teaching is supervised by the PTE mentor.

4D The PTE curriculum includes multiple required guided inquiry physics courses taught by the program leader, who has many years of high school physics teaching experience.

Mentoring and Professional Support (Standard 5)

5A, 5B Teacher candidates are personally inspired and closely advised and mentored by the PTE program leader, who has many years of high school teaching experience.

Program Structure. The College of Physical and Mathematical Science coordinates with the McKay School of Education to provide a "physics or physical science teaching major," incorporating both a major and a professional education program leading to eligibility for teacher licensure.

Secondary education majors graduate with a teaching degree in their discipline; for example, a "physics teaching major" graduates from the Physics Department with a B.A. (or B.S.) leading to licensure. The physics teaching major includes multiple early teaching experiences and multiple physics teaching methods courses, which are taught by the faculty leader of the physics teacher education program.

NARRATIVE

Institutional Commitment. Brigham Young University has an extraordinary history of physics teacher education, producing on average approximately 15 physics teachers per year since the current faculty leader arrived in 2004. Some of this success is likely due to BYU students' strong service orientation and the high value that LDS culture places on teaching, which is reflected in the mission of the university (1A).

Recruitment. Most students arrive at the university after a two-year mission experience, which is often understood as a teaching experience. There is also a large number of physics majors (3A). The Physics Department sees physics teaching as a primary, fulfilling career, not a "backup plan" (3B). For example, in a recent departmental assessment, the department strongly affirmed the value of a teaching career by rejecting external reviewers' assessment that physics teacher candidates should be offered "better opportunities."

Leadership and Mentoring. Physics teacher education at BYU began in earnest with the arrival of the current faculty leader, Duane Merrell, whose charisma, K–12 experience, and pedagogical content knowledge are a major strength of the program (2B). Merrell connects with the students and gets them excited about physics teaching as a profession (3B). He also teaches the physics teaching methods courses (4B), closely advises and mentors teacher candidates (5A, 5B), and collaborates with five local school districts for mutually beneficial programs (2B). For example, in two-year rotations a different local physics teacher serves the BYU PTE program as a full-time physics Teacher in Residence (2A), and the BYU PTE program provides a recent physics teacher graduate to take that teacher's place for the year.

Pedagogical Preparation. BYU has a system of secondary education majors, in which the School of Education coordinates with the Physics Department (among numerous other departments) to provide disciplinary majors that also incorporate professional education leading to teacher licensure.

The physics teaching major is a popular and well-promoted option in the Physics Department (3B). Coursework for the physics teaching major includes multiple guided inquiry physics courses taught by the faculty leader (using the Modeling Physics and other physics by inquiry curricula; 4B) and multiple field teaching experiences (4C). The faculty leader has decades of K–12 teaching experience (2B, 4B, 5B); his experience strengthens his science methods instruction (4B) and his mentoring capacity (5B).

Recognition and Rewards. Merrell is highly esteemed by the university, the college, and his department, having recently been promoted to full professor for his work in physics teacher education in spite of his nontraditional background (1B). The College of Arts & Sciences recently awarded Merrell a prestigious teaching award for his physics teacher education activities (1B). The institution also supports PTE by funding teacher professional development, outreach activities, and the redesign of classrooms that benefit future physics teachers (1A) and has featured physics teacher education in its glossy magazine (1B).

California Polytechnic University, San Luis Obispo

California Polytechnic University, San Luis Obispo (SLO) is a public polytechnic university located in San Luis Obispo (in southern California). The total student enrollment is 21,000.

PROGRAM OVERVIEW

Program Context. California does not require physics for high school students, so at some schools, physics teachers have to justify their existence. California requires physics teachers to have a bachelor's degree but does not require that the degree be in physics; instead, teacher candidates must pass a content exam.

Certification Options. The typical certification option is a single-subject credential in physics. Students may elect to add other single-subject credentials (such as math or chemistry) to qualify to teach other subjects. A bachelor's degree (B.A. or B.S.) is required for certification, but the degree need not be in the single-subject area. Physics content knowledge is evaluated with a physics exam.

The program visit for the PTEPA Rubric occurred in May 2017 and was conducted in person by Rachel E. Scherr.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A A well-funded Center for Engineering, Science, and Mathematics Education (CESAME) has overseen STEM teacher education for more than 15 years. STEM teacher education is vigorously supported by the dean of the College of Science and Mathematics.

1B Multiple disciplinary faculty have been hired and sustained based on their STEM education activities.

Leadership and Collaboration (Standard 2)

2A The physics teacher education leadership team includes multiple tenured faculty in physics, one of whom is the director of CESAME, and a long-term Teacher in Residence.

2B STEM teacher education programs are run by disciplinary faculty with strong STEM education identities.

2C STEM teacher education programs are run by boundary-crossers and are the basis for effective collaboration between CESAME and the disciplinary departments.

2A, 2B There is a physics Teacher in Residence (TIR) who intersects with teacher candidates in multiple settings, including teaching science methods courses and overseeing student teacher placement.

Recruitment (Standard 3)

3A There are many physics majors and physics-like majors who create a large pool of potential teacher candidates.

3C Numerous popular high-quality early teaching experiences recruit students into science teaching and develop their pedagogical skills.

Knowledge and Skills for Teaching Physics (Standard 4)

4D Student teacher experiences are supervised by a highly experienced TIR.

Program Structure. The primary physics teacher preparation program is a B.S. or B.A. followed by a one-year post-baccalaureate program. The bachelor's degree may be in physics or a physics-like subject; half the physics teacher candidates at SLO are engineering majors. The postbac does not produce an additional degree.

Students are not formally identified as future teachers while they are undergrads; they may participate in a variety of early teaching experiences, but many students participate in these without intending to pursue a career in teaching. The first formal identification as a teacher candidate is entry into the postbac program.

STEM teacher education is a primary responsibility of the Center for Engineering, Science, and Mathematics Education (CESAME), which also oversees outreach, mentoring, and field teaching opportunities. The postbac program is overseen by the School of Education, which is a graduate-only school in the College of Science and Mathematics.

SLO typically produces 3–4 physics teachers per year. SLO was a PhysTEC-supported site starting in 2003. For more information visit PhysTEC's informational page about SLO[11] or the CESAME website.[12]

NARRATIVE

Local Context. Local factors in southern California provide some support for SLO to produce highly qualified physics teachers and also some limiting factors. The state of California does not require physics teachers to have a physics major. However, No Child Left Behind requires strong subject matter competency, meaning there is more demand for physics teachers to have a physics major than a decade ago. California students are not required to take physics, so physics teachers have to justify their existence by creating demand for physics in their schools (promoting physics to principals, students, and parents). Physics teachers may teach only physics in an urban school or a mix of physics and other sciences or math in a rural school. For the many students who want to stay in the San Luis Obispo area, teaching is a good means to do so (and there is no option to stay in the area for physics graduate school). As a result, SLO is surrounded by many local teachers who host field experiences (4C).

Recruitment. As a polytechnic university, SLO has a large physics program that attracts many majors (3A)—about 150 per year, as well as a very large number of engineering majors (about 6,000 per year) who can equally qualify to be physics teachers in California (3A). Together, these majors constitute a large pool of potential physics teacher candidates.

Physics teacher education at SLO takes place primarily in a one-year post-baccalaureate program (3D), which candidates enter after obtaining a B.S. or B.A. in physics or a physics-like subject (4A). There is no undergraduate involvement in physics teacher education and no physics Learning Assistant program. The post-baccalaureate physics teacher education program is administered by the School of Education, which is within the College of Science and Mathematics. In the postbac program, teacher candidates work closely together and form a strong cohort (5B). Strengths of the program include student teaching hosted by highly qualified physics teachers in the area, many of whom are program graduates (4D).

Institutional Commitment. STEM education activities, including teacher education and outreach, are brought together under the umbrella of CESAME, a well-funded center that has supported physics teacher education for about 15 years (1C) as part of the university's mission to strengthen STEM education in California schools. The success and stability of CESAME demonstrate SLO's strong institutional commitment to STEM teacher education, with physics teacher preparation as an explicit component (1A). This commitment to STEM teacher education permeates the whole College of Science and Mathematics, from the concrete support of the dean (1A) to the day-to-day work of the staff (1C).

Early Teaching Experiences. A hallmark of the SLO PTE program is the variety of high-quality, popular, well-funded early teaching experiences that recruit students into science teaching (3C) and develop their pedagogical skills (4C). These programs are not physics-specific; they include all the sciences, which gives them critical mass, but this also means that only a small fraction of participants is physics-identified. Programs include the Learn By Doing Lab (LBDL), in which 100 undergraduates per year are mentored to design science lessons for 5th–8th grade students who come to campus; Teacher Assistants in Math and Science (TEAMS), in which undergraduates assist in 7th–12th grade classrooms; and Mentors in Out-of-School Time (MOST), in which undergraduates teach STEM-focused modules in an after-school program at a local school. Many undergraduates participate in these experiential learning programs, whether or not they intend to pursue a career in teaching.

Program Team. These programs are run by disciplinary faculty with strong STEM education identities, who are supported and rewarded for their physics teacher education activities (1B). These boundary-crossers are the basis for effective collaboration between CESAME and the disciplinary departments (2C). Members of the physics teacher education leadership team include multiple tenured faculty in physics (including the director and co-director of CESAME) and a long-term physics TIR who intersects with teacher candidates in multiple settings (2A, 2B). As a group, the team of leaders in STEM teacher education is deeply involved with local schools, engaging with superintendents, principals, and teachers in 12 different school districts (2B).

CASE STUDY

Georgia State University

Georgia State University (GSU) is a public research university located in downtown Atlanta. It is an urban institution with a diverse student population. It is the largest of the four research universities in the University of Georgia system, with a total undergraduate enrollment of 25,000.

PROGRAM OVERVIEW

Program Context. GSU's urban location creates many local job opportunities for teacher candidates. There is state-level attention (from the governor's office) to the need for qualified physics teachers. Teachers are well paid in Georgia, with nine-month starting salaries in the $42,000–$45,000/year range in Atlanta. Thus, program graduates are nearly guaranteed a job upon graduation, at a good salary, without needing to relocate.

Certification Options. Graduates from the B.S. in physics teacher education concentration are certified to teach physics and physical science at the grade 6 to 12 level. Students completing the Master of Arts in Teaching Science Education program can be certified in one or more sciences or broad field (all four sciences).

The program visit for the PTEPA Rubric occurred in February 2017 and was conducted in person by Stephanie Chasteen.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Leadership and Collaboration (Standard 2)

2A, 2B, 2C The PTE team is led by a tenured faculty member with expertise in physics education who collaborates well with the School of Education.

2A, 2B A part-time TIR interacts with students during their methods coursework and student teaching, providing critical connection to physics teaching expertise.

2C Faculty in both physics and education lead the program, and there are clear agreements regarding how students are advised within physics and education as they complete program requirements in parallel.

2C A formal structure (the Professional Education Faculty) represents all units with a stake in teacher preparation, offering a mechanism for cross-college collaboration and decision-making.

Recruitment (Standard 3)

N/A A locally strong climate for physics teaching careers (high local salary, strong local demand) creates an influx of interested future physics teachers.

3B Physics students are readily exposed to the idea of physics teaching as a career pathway within the department through the LA program, announcements in core courses (including the general non-majors' course), and flyers.

3C An education concentration within the physics B.S. provides students a clear pathway towards licensure within 4–5 years.

Mentoring and Professional Support (Standard 5)

5A, 5B The student advisor is also the PTE program leader and is deeply knowledgeable about certification pathways, enabling him to effectively advise students both about completion of their physics degrees and PTE requirements. Teacher candidates are co-advised in physics and education.

5B A part-time TIR provides the relevant K–12 expertise for physics teaching mentorship.

Program Structure. Undergraduate physics students at GSU can become licensed to teach physics by obtaining a B.S. in physics with an education concentration. Certification requirements are completed through the School of Education beginning in the junior year, with graduation possible in four years.

Physics is the only STEM field in which there is an undergraduate path to licensure within the university. A master's level (Master of Arts in Teaching; MAT) track is also available for those who already hold their undergraduate degree, and this draws some students from neighboring Georgia Tech.

GSU has been a member of the 5+ Club and was a PhysTEC-funded site, with funding ending in 2016. More information about GSU's teacher preparation program is available at the PhysTEC's informational page about GSU.[13]

NARRATIVE

Georgia State University (GSU)'s physics teacher education program draws from a favorable local climate for physics teaching, including high local salaries ($50,000–$60,000/year) and a strong local need for physics teachers. Thus, program graduates are almost assured of being able to find employment with a good salary near the university upon graduation. "We started the undergraduate track, and there was a line of students at the door," says program leader Brian Thoms.

Institutional Commitment. This supportive local climate is strengthened by institutional commitment, strong collaboration between physics and education, and a passionate and knowledgeable faculty team. There is state-level attention to the need for qualified physics teachers due to a 2009 state bill (signed by the governor) providing pay increases for science teachers and specifically calling for increases in physics teacher production. GSU is also one of 14 institutions in the state university system that states "increased STEM teacher production" as a central goal[14] (1A).

Leadership. GSU's PTE program is led by a dedicated physics faculty member (Brian Thoms). Thoms is personally passionate about physics teaching, acts as an energetic advocate for the program, has expertise in physics education and physics education research (2B), and is engaged in PhysTEC. As a tenured faculty member and associate chair, Thoms has positional power (2B) and is able to spearhead a variety of undergraduate initiatives, including an increase in the number of undergraduate majors and a focus on the preparation of physics teachers. Thoms is supported by a diverse team (2A), which includes a part-time Teacher in Residence and faculty in the School of Education (2C).

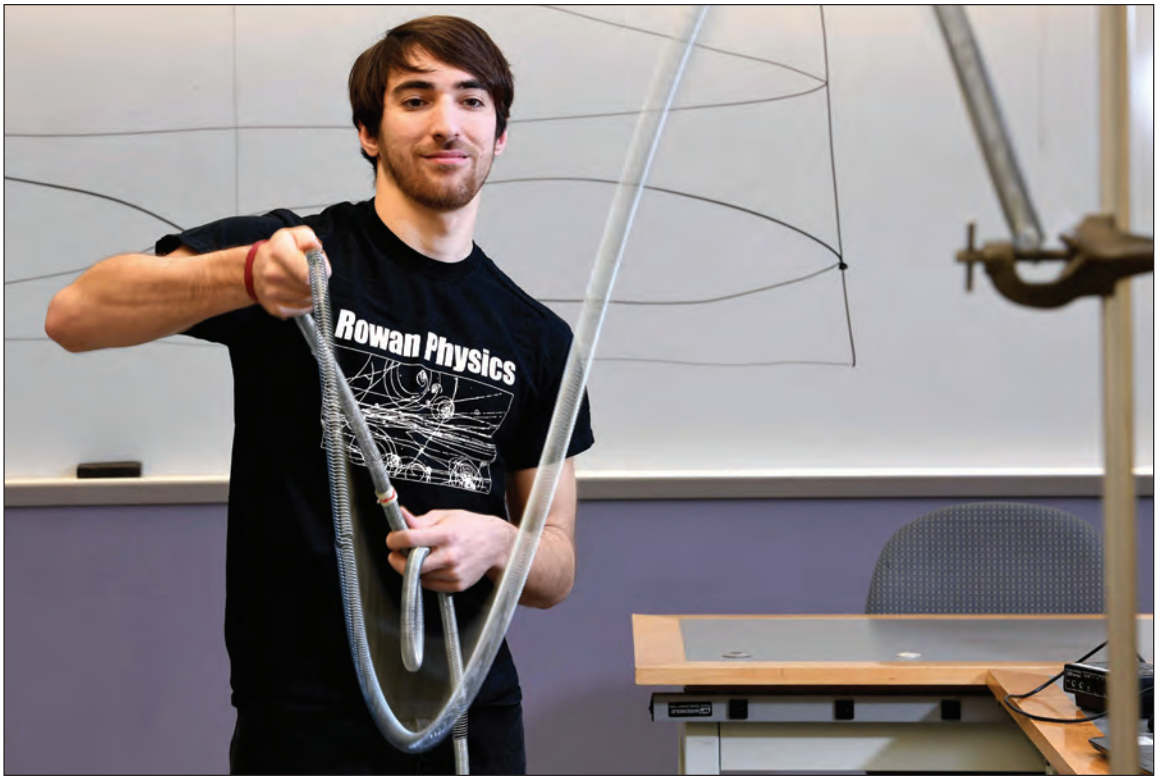
Collaboration. There are multiple points of collaboration between physics and education at GSU (2C), with team members able to call on one another easily, giving joint talks, and collaborating on grants and dissertation committees. A formal committee structure (the Professional Education Faculty) enables regular interaction and decision-making between the School of Education and disciplinary units involved in teacher education (such as physics). This group provides a clear pathway for disciplinary units to give input on (for example) field experiences for teacher candidates. The program leader (Thoms) served until recently as chair of the executive committee of that group.

Recruiting. Students are actively recruited into teaching (3B) through announcements in core courses (including the non-majors' courses), a Learning Assistant program, advising, and encouragement from multiple faculty members. The physics program has grown in the past five years, providing a greater recruitment pool (3A).

Mentoring. As the undergraduate advisor, Thoms acts as a positive ambassador for the profession (3B) and can give students both effective advising regarding the physics program (5A) and clear information about a pathway towards licensure (3B, 5B). His direct connection to students and deep knowledge of physics and education requirements allow him to give students personalized attention and help them remove barriers towards achieving their degree in minimal time. Thoms consistently communicates with deans about program successes (6C); this communication, plus the statewide attention to teacher preparation, has ensured strong institutional commitment across the colleges (1A).

CASE STUDY

Rowan University



Rowan University is a comprehensive public regional university located in Glassboro, New Jersey. The total student enrollment is 18,000.

PROGRAM OVERVIEW

Program Context. Rowan University was originally created as a normal school for teacher education; it is still the largest teacher education program in the region and the only one offering specialized certifications. A large gift to the university in the 1990s added a significant focus on engineering, and since that time, the number of physics majors has increased to over 150 per year.

Certification Options. The typical certification option is a physics or physical science certification. The physical science certification enables teachers in New Jersey to teach both chemistry and physics.

The program visit for the PTEPA Rubric occurred in February 2017 and was conducted through phone interviews by Rachel E. Scherr.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A STEM teacher preparation is an explicit part of the strategic plan for the College of Science & Mathematics. There is a STEAM Education department specifically focused on the education of science teachers.

1A Support for Learning Assistants has been institutionalized in the budget of the College of Science & Mathematics.

1B One of the PTE program leaders was hired for his work in physics teacher education and is supported to conduct research in physics education.

1C The PTE program team includes a full-time staff member.

1C There is a dedicated space for physics education research, which is frequented by physics teacher candidates.

Leadership and Collaboration (Standard 2)

2A, 2B The PTE team includes a dean, the physics chair, a physics education researcher, and multiple personnel with decades of high school teaching experience, including two TIRs.

2B The TIR is deeply integrated into the program, engaging in active mentorship, recruitment, outreach activities in high schools, and student teaching supervision.

2B The program is highly engaged with Glassboro High School, which is across the street.

2B Multiple members of the team are current or former high school physics teachers, and one is a physics education researcher.

2B Two full-time PTE program team members are boundary crossers; one is a faculty member with a joint appointment in physics and education.

2C Student teacher placement is influenced by a PTE mentor.

Recruitment (Standard 3)

3A There are large numbers of physics and physics-aligned majors.

3A Students are actively recruited into the PTE program from multiple departments.

3B Multiple physics faculty are strong supporters of physics teacher education who share in detail options for becoming a physics teacher. They are also positive ambassadors for the teaching profession, with multiple decades of teaching experience.

3C Glassboro High School is across the street, and all LAs get field experience there.

3D The Physics Department promotes three tracks—graduate school, industry, and physics teaching—with equal weight, supported by degree options and advising structures.

Knowledge and Skills for Teaching Physics (Standard 4)

4A All of the physics majors' introductory physics courses use research-based teaching methods.

4A Participation in physics education research is the standard practice for physics teacher candidates, including poster presentations connecting research to instructional practice.

4C, 4D There are many cooperating teachers in the area for field experiences and student teaching.

4D The university supervisor for student teaching is a member of the PTE program team.

Mentoring and Professional Support (Standard 5)

5A, 5B A clear advising structure supports students in career plans and includes two years with a staff advisor and two years with a faculty mentor. Scholarship opportunities are robustly advised.

5B Physics teacher candidates collaborate in weekly LA meetings and courses, attend outreach events together, and share a student lounge as well as dedicated space for physics education research.

5B Physics teacher candidates interact with working teachers several times a year through the Rowan Area Physics Teachers (RAPT) program.

Program Structure. The Physics Department has three established tracks of undergraduate study: one for students planning to go to graduate school, one for students planning to go into industry, and one for students planning to pursue high school physics teaching.

Until 2017, the physics teacher education program was either (1) a double major in physics (on the teaching track) and secondary education, which took 4–5 years, or (2) a physics major (or minor) followed by an M.A. in STEM teaching (3–4 years plus one year). As of fall 2017, only the second option is available. STEM teacher education is a primary responsibility of the STEAM Education department in the College of Education.

Rowan was a PhysTEC-supported site starting in 2015 and produced five PhysTEC graduates in its first year of the award, primarily due to an attractive stipend opportunity (the Woodrow Wilson Fellowship). For more information visit PhysTEC's informational page about Rowan,[15] the Rowan STEAM Education website,[16] and the Rowan Physics Department website.[17]

NARRATIVE

Institutional Commitment. Rowan University has a strong history of and reputation for teacher preparation (3A), having been founded as Glassboro Normal School (a teacher education institution). Today, it has by far the largest teacher education program in South Jersey and is the only one that offers specialized education degrees; almost any student in South Jersey has had a teacher who graduated from Rowan.

STEM teacher education has its own department in the College of Education and is part of the explicit mission of the College of Science & Mathematics (1A). In addition, as a result of a substantial gift in the 1990s, Rowan has a sizeable engineering program, which contributes to the large number of physics majors (over 150/year and growing; 3A).

Physics Department. Rowan's physics teacher education benefits from a physics department that explicitly promotes three career tracks with equal weight—physics graduate school, physics industry, and physics teaching—supported by degree options (3D) and advising structures (5A). The Physics Department has small classes and a strong culture of active engagement. The PTE program is led by a powerful team of strong supporters of physics teaching, including a dean, the physics chair, other physics faculty including a physics education researcher, and two TIRs (2A, 2B). Multiple team members, including physics faculty, have decades of K–12 teaching experience and are positive ambassadors for a physics teaching career (3B).

Recruitment. Students at Rowan are actively recruited into physics teaching partly through a large Learning Assistant program (3C), which recruits from multiple departments (3A). All Learning Assistants meet weekly to discuss physics pedagogy, and many take a course which includes physics pedagogy (4B). LAs who are also teacher candidates get field experience in physics at Glassboro High School, conveniently located right across the street (3C). They are mentored by a physics teacher who is also part of the PTE team (2A, 2B). Students can also experience the scholarship of teaching by doing undergraduate research with a faculty member who specializes in physics education research (2B).

Licensure Pathways. Physics teacher education at Rowan has enjoyed the benefit of multiple pathways to endorsement, either (1) a double major in physics (on the teaching track) and secondary education, which took 4–5 years, or (2) a physics major (or minor) followed by an M.A. in STEM teaching (3–4 years plus one year) (3D). Unfortunately, as of fall 2017, the undergraduate-only pathway has been removed. This may make it more difficult for the Physics Department to identify and support students who might pursue a teaching career. However, there is a state-accredited alternate route for students hired by school districts without completing the M.A. STEM certification path.

CASE STUDY

Rutgers University

Rutgers University, The State University of New Jersey (Rutgers), is a public research university located in Brunswick, New Jersey. The total student enrollment is 66,000.

PROGRAM OVERVIEW

Program Context. Teacher salaries in the region are high (starting at $55,000), and jobs for physics teachers are plentiful.

Certification Options. Rutgers provides certification for physics and physical science (which allows graduates to teach physics and chemistry). The state of New Jersey has an additional secondary STEM certification in chemistry that is not offered by Rutgers. Unlike some New Jersey institutions, Rutgers is only able to offer master's-level teacher certification (no undergraduate degree option in education is allowed) due to a historical, elective agreement.

The program visit for the PTEPA Rubric occurred in March 2017 and was conducted virtually by Stephanie Chasteen.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A Science teacher preparation in the Graduate School of Education was split into biology and physics, enabling physics-specific preparation and dedication of a faculty member to that program.

1B, 1C The program leader's permanent position is dedicated to physics teacher preparation, providing significant time to the endeavor. This represents a substantial, recurring line item expense on the part of the institution.

1B A member of the PTE team in the Physics Department was promoted in part due to his work with the PTE program.

Leadership and Collaboration (Standard 2)

2A Program leadership is knowledgeable, influential, and passionate.

Recruitment (Standard 3)

3A The long history and strong reputation of the program draws students.

Knowledge and Skills for Teaching Physics (Standard 4)

4B The curriculum is rigorous and focused on physics pedagogy across six courses using inquiry methods of teaching and learning. The coursework builds strategically across topics and is well aligned with experiential learning opportunities.

4B Courses are taught by the program leader and program graduates, all of whom have physics K–12 teaching experience.

4C, 4D The long history of the program creates a pool of high-quality area teachers to mentor student field teaching experiences (including student teaching).

4C, 4D Students have many experiential learning opportunities, including peer teaching ("microteaching"), Teaching Assistantships, and student teaching with program graduates. Candidates engage in teaching physics every semester of the program.

4B, 4C, 4D All teaching opportunities are high quality, occurring in classrooms using inquiry methods. Examples include peer teaching in pedagogy courses, the opportunity to serve as TAs in a reformed introductory physics course, or the chance to teach high school classrooms as program graduates.

Mentoring and Professional Support (Standard 5)

5B Students are individually mentored by the program champion, who serves as their advisor and teaches core courses.

5C In-service teachers receive regular, informal mentoring through "Friday meetings" to improve their practice.

Program Structure. Rutgers has two physics teacher preparation programs: a five-year Masters of Education along with teaching certification and a two-year post-baccalaureate Masters of Education plus teaching certificate program.

The program is housed in the Graduate School of Education with significant collaboration with the Office of Teacher Education in order to fulfill licensing requirements and place student teachers.

Rutgers has been a member of the 5+ Club for the past 10 years and is a member institution of PhysTEC, but it has not been a PhysTEC-supported program. Visit PhysTEC's informational page about Rutgers' program[18] or the Rutgers Teacher Education website[19] for more information.

NARRATIVE

Leadership. The Rutgers teacher education program is led by Eugenia Etkina, a faculty member in the Graduate School of Education; Etkina is an effective local champion (2A, 2B) with positional power and a national reputation in the field who also has expertise in physics, physics education research, and K–12 education. She is personally passionate about physics teacher education and serves as advisor for students in the program.

Curriculum. A hallmark of the Rutgers program is the intensive focus on physics content and pedagogy; there is a high-quality physics pedagogy curriculum (4B), with a total of six courses (18 credits) focused on physics pedagogy using the Investigative Science Learning Environment (ISLE) approach pioneered by Etkina. These pedagogy courses are taught by staff with K–12 teaching experience (Etkina and her graduates; 4B). The curriculum is consistent and aligned across courses (4B-6) to ingrain effective teacher habits over time and includes a focus on re-learning physics content using inquiry approaches, which also results in deep physics content learning (4A). Etkina has solicited feedback from students and improved the program over time (6B). Employers of Rutgers' graduates remark on the excellent preparation of these students.

Institutional Commitment. The strong focus on physics content within the Rutgers program was enabled by an explicit focus on physics teacher preparation in the Graduate School of Education (1A). In 2002, faculty in the Graduate School of Education began to separately prepare physics teachers and biology teachers. The original proposal to provide discipline-specific preparation (submitted by Etkina) was met with skepticism on the part of many education faculty, as they were concerned that this was an unusual structure and would reduce the number of students enrolling.

The faculty decided to experiment with the structure, in part due to the national reputation of their champion (2B). The success of this approach, as well as a dean's careful protection of the program, has led to long-term sustainability of the structure despite the obvious financial drawbacks of smaller classes. The location of the program within the Graduate School of Education allows it to leverage significant resources (1C), particularly administrative staff, dedicated program space, and budget for its instructional staff.

Collaboration. Additionally, long-term collaboration with the Physics Department (2C) has been vital to the program, including long-term departmental agreements and engaged partner faculty. The PTE program collaborates with physics to provide teaching experiences; PTE students serve as Teaching Assistants within a reformed introductory course in Physics (3B) to co-advise undergraduate majors in the PTE program (3C, 5B). Additionally, a functional working arrangement between the Office of Teacher Education and the physics teacher program ensures that teacher candidates meet certification and licensing requirements and are appropriately placed with cooperating teachers for field and clinical experiences (and ensures students are tracked).

Experiential Learning. Another hallmark of the Rutgers program is multiple, mentored experiential learning opportunities for teacher candidates. Teacher candidates practice "microteaching"—short lessons delivered to peers—throughout the curriculum and serve as TAs for an inquiry-based introductory physics course (4B). This TA experience is supported by the existence of a knowledgeable and committed partner in the Physics Department (2C), who provides this early teaching experience and mentors students within it.

Additionally, students are individually placed with high-quality teachers for student teaching (4D), enabled in large part by the longevity of the program, which has created a concentration of program graduates in the local area. These experiential learning opportunities are individually mentored by Etkina (5B).

Reputation and Recruitment. The long history and reputation of the program are great assets in several ways. First, the program can draw on local teachers who are graduates of the program to serve as cooperating teachers for student field placements (4C, 4D). Second, many students are drawn by the strong reputation of the program; some are former students of program graduates (3A). Additionally, the program draws on a strong recruitment network (3A); the physics undergraduate director proactively refers interested students to Etkina. Etkina visits the Society of Physics Students (SPS) club every year to recruit potential candidates (3B), and when students speak to her about an interest in teaching, she is known to be good at convincing people to become teachers. These mechanisms serve as the main recruiting methods, rather than early teaching experiences (such as the LA program).

The Physics Department has supported a streamlined path to graduation (3D) by having an undergraduate option to attain a B.A. in physics with fewer credit requirements.

Mentoring. Within the program, students receive individualized mentoring (5B), with Etkina serving as their advisor (or co-advisor along with their physics advisor). Etkina knows students personally and holds them to high standards, providing critical individual feedback for improvement. In speaking with program graduates, it's clear that meeting Etkina's high standards becomes a matter of professional pride for her students, who see teaching as a challenge worthy of mastery.

Community. A strong community among teacher candidates (5B) is supported through intensive collaboration in coursework and frequent social events, and in-service teachers are able to receive informal mentoring (5C) through monthly "Friday meetings" where they discuss teaching challenges and reinvigorate their practice.

Assessment. The program is continually improved with feedback from students and alumni (6B). Etkina maintains close relationships with program alumni and interacts with local districts, providing useful feedback. She also publishes regularly about physics teacher education in the scholarly literature. These, as well as ongoing critical reflection on the program and its outcomes, have informed ongoing revisions to the curriculum and approaches.

CASE STUDY

Stony Brook University

Stony Brook University is a public research university located in Stony Brook, New York (on Long Island). The total student enrollment is 25,000.

PROGRAM OVERVIEW

Program Context. New York State requires all physics teachers to have a major in physics. Teacher salaries and placement in the region are very good.

Certification Options. The typical certification option is a single-subject credential in physics. Some students elect to obtain a secondary credential in another subject (such as math or chemistry). New York State requires all physics teachers to have a physics major.

The program visit for the PTEPA Rubric occurred in April 2017 and was conducted remotely by Rachel E. Scherr.

EXEMPLARY PRACTICES

Below are the particularly strong elements of this program on the PTEPA Rubric.

Institutional Commitment (Standard 1)

1A STEM teacher education is built into the institutional structure in the form of a well-funded Institute for STEM Education (I-STEM) that has overseen the education of science teachers for more than 25 years.

1B A member of the program team has been promoted based in large part on her PTE activities.

1C Institutional funding for the Institute for STEM Education (I-STEM) is stable and long-term.

Leadership and Collaboration (Standard 2)

2A Members of the physics teacher education leadership team include multiple tenured faculty in physics, the director of I-STEM, and multiple physics Teachers in Residence.

2B Multiple members of the PTE leadership team are certified physics teachers with high K–12 school engagement.

2B Teachers in Residence are highly integrated into the program and intersect with teacher candidates in multiple settings; for example, one teaches a three-credit graduate-level physics-specific pedagogy course, and another is responsible for student teacher placement.

2C I-STEM is comprised of faculty with joint appointments in disciplinary departments, providing the basis for effective collaboration between these units.

Knowledge and Skills for Teaching Physics (Standard 4)

4A By state requirement, a physics major is required for teacher candidates. (The university requires even more physics credits than the state does.)

4B A physics-specific pedagogy course is required for physics teacher candidates and is taught by a Teacher in Residence (TIR).

4D There are many teacher partners in the region for student teacher placement.

4D The university supervisor (who oversees student teaching) is a member of the PTE program team and an experienced physics TIR.

Program Structure. The primary physics teacher preparation program is a B.S. in physics followed by an 18-month post-baccalaureate in which participants earn a Master of Arts in Teaching Physics and a physics (single-subject) certification. Graduates of the program are licensed to teach physics in grades 7–12.

The physics teacher education program is housed in the Institute for STEM Education (I-STEM), an interdisciplinary STEM education center that oversees the education of all science teachers and also conducts outreach programs. There is no school of education; the MAT program and teacher certification are administered by a School of Professional Development.

Stony Brook University typically produces 2–4 physics teachers per year but recently moved into the 5+ Club as a result of Noyce fellowships. Stony Brook University is a PhysTEC member institution but has not been a PhysTEC-supported program. For more information, visit PhysTEC's informational page about Stony Brook University's program[20] or the I-STEM website for prospective teachers.[21]

NARRATIVE

Local Context. Local factors in New York State and in the Long Island region support Stony Brook University in producing many highly qualified physics teachers. Teaching is a good job in New York State: not only are there many positions available, but also, they pay well and are stable. The state of New York offers multiple physics courses in high school and requires all new physics teachers to have a physics major or credit equivalent (4A). Physics teachers frequently teach only physics. A thriving regional physics teacher association (the Long Island Physics Teacher Association, LIPTA) provides professional community for working teachers (5B). The Long Island area has very high expectations for teacher quality and educational quality in general. As a result, Stony Brook University is surrounded by many local teachers who host field and student teaching experiences and provide professional community for candidates (4C, 4D, 5B).

Recruitment. Stony Brook University has a well-regarded physics program that attracts many majors (3A) and has a reputation for rigorous content preparation (4A). This undergraduate physics program provides a large pool of potential physics teacher candidates.

Licensure Pathway. Physics teacher education at Stony Brook University takes place primarily in an 18-month post-baccalaureate program, which candidates enter after obtaining a B.S. in physics. There is little undergraduate involvement in physics teacher education. The post-baccalaureate physics teacher education program is housed jointly in the Physics Department and in the Institute for STEM Education (I-STEM), a well-funded institute that has overseen the education of science teachers for more than 25 years (1A, 1C).

Institutional Commitment. The success and stability of I-STEM demonstrates Stony Brook University's strong institutional commitment to STEM teacher education, with physics teacher preparation as an explicit component (1A). I-STEM is comprised of faculty with joint appointments in disciplinary departments, who are supported and rewarded for their physics teacher education activities (1B). For example, a physics faculty member responsible for physics teacher education recently received a New York State Chancellor's Award for Teaching Excellence. These boundary-crossers are the basis for effective collaboration between I-STEM and the disciplinary departments (2C).

Leadership. Members of the physics teacher education leadership team include multiple tenured faculty in physics (one of whom is also a certified physics teacher), the director of I-STEM (also a certified physics teacher), and multiple physics Teachers in Residence who intersect with teacher candidates in multiple settings (2A, 2B). For example, one physics Teacher in Residence teaches a three-credit graduate-level physics-specific pedagogy course (4B), and another is responsible for student teacher placement (4D).

Pedagogical Preparation. In Stony Brook University's 18-month post-baccalaureate physics teacher education program, teacher candidates work closely together and form a strong cohort (5B). Strengths of the program include a state-required 100 hours of observation in schools, which usually includes active participation as an assistant teacher; thus, all Stony Brook University physics teacher candidates have significant field experience (4C) once they are in the program. Both field experiences and student teaching are hosted by highly qualified physics teachers in the area, many of whom are program graduates (4C, 4D).

ENDNOTES

1 See www.phystec.org/the5plus/.
2 Available at www.phystec.org/institutions/institution.cfm?ID=86.
3 See uteach.utexas.edu/.
4 See institute.uteach.utexas.edu/uteach-elements-success.
5 See https://www.colorado.edu/cuteach/.
6 Available at https://www.colorado.edu/physics/EducationIssues/phystec/.
7 See https://www.phystec.org/institutions/institution.cfm?ID=93.
8 See https://laprogram.colorado.edu.
9 Available at http://colorado.edu/sei.
10 See https://www.colorado.edu/cuteach/.
11 See https://www.phystec.org/institutions/institution.cfm?ID=55.
12 Available at https://cesame.calpoly.edu/.
13 See https://www.phystec.org/institutions/Institution.cfm?ID=568.
14 Available at https://www.usg.edu/academic_affairs_and_policy/stem/participating_institutions.
15 See https://www.phystec.org/institutions/institution.cfm?ID=800.
16 Available at https://academics.rowan.edu/education/programs/departments/STEAM/index.html.
17 See https://academics.rowan.edu/csm/departments/physics/index.html.
18 See https://www.phystec.org/institutions/institution.cfm?ID=71.
19 Available at https://gse.rutgers.edu/academic-programs/five-year-teacher-education/physical-science-and-physics-education-k-12.
20 See https://www.phystec.org/institutions/institution.cfm?ID=750.
21 Available at http://www.stonybrook.edu/commcms/istem/students/prospective_teachers/prospective_teachers.php.

APPENDIX 4

Accreditation Review: Validation of the PTEPA Rubric Process and Interpretation

The organization and interpretation of the PTEPA Rubric are consistent with and informed by the academic community's approaches to accreditation.

INTRODUCTION

Anthony Ribera, PhD, provided a synthesis of accreditation processes in higher education and used this synthesis as a basis for recommendations for the PTEPA Rubric. Though the PTEPA Rubric is not associated with an accreditation process, his review provided valuable recommendations for interpreting the rubric results, for evaluating when a program "passes" a component or standard, and for best practices in completing the PTEPA Rubric.

ACCREDITATION AND REVIEW PROCESSES EXAMINED

Dr. Ribera reviewed the processes associated with accreditation by several organizations (such as the Accreditation Board for Engineering and Technology; ABET) as well as processes used for program review by some organizations that are not accrediting bodies (such as the National Institute for Learning Outcomes Assessment; NILOA). These are shown in Table 7.

Although Dr. Ribera reviewed the processes used by several organizations, many recommendations in this appendix stem from NILOA's process. This is the newest process, and likely because of the involvement of assessment and institutional research professionals, it is a well-developed process.

Table 7. Accreditation and review processes examined.

Organization	Programs/Efforts Reviewed
Accreditation Board for Engineering and Technology (ABET) Commission	Undergraduate engineering programs
Accrediting Commission for Community and Junior Colleges	Community/junior colleges
American Council on Education	Course quality assessment
American Dental Association	DDS programs
American Occupational Therapy Association	Occupational therapy programs
Association to Advance Collegiate Schools of Business	Business schools
Council for the Accreditation of Educator Preparation (CAEP)	Teacher education programs
Council for the Advancement of Standards in Higher Education (CASHE)	College student affairs functional areas (e.g., housing, study abroad)
Higher Learning Commission (HLC)	Colleges and universities
Liaison Committee on Medical Education	MD programs
National Institute for Learning Outcomes Assessment (NILOA)	Campus-level assessment

ACCREDITATION PROCESSES

For the majority of the accrediting processes reviewed, the local institution submits their results to a review team at the accrediting body. That review team reviews the institution's results and makes a recommendation to a larger committee that then makes the final accreditation decision. For instance, as part of the process associated with CAEP, the review team presents findings to the Accreditation Council, which is then charged with making the final decision.

One overarching theme from the accrediting bodies and literature reviewed by Dr. Ribera is that processes must rely on multiple data sources from a variety of stakeholders in order to accurately determine accreditation status. NILOA identifies stakeholders (e.g., student affairs professionals, faculty, and alumni) who should serve on the campus application team and collects this information in a narrative report that is reviewed and scored by raters.

Another theme is that accrediting bodies recognize the effort involved for programs to complete accreditation and provide resources to support programs in this effort. For example, the American Occupational Therapy Association provides timelines, papers, and webinars to help institutions complete the process.

Some additional features of the accreditation process include:

1. Written and verbal communication between the review team and the institution before, during, and after review, including a lengthy narrative self-study report by the institution.

2. Learners (i.e., students) are actively engaged in the accreditation process. As part of the Liaison Committee on Medical Education process, students are required to independently create, administer, analyze, and report findings from an independent student survey.

3. Within accreditation processes, there are opportunities to identify areas in need of attention and improvement strategies in addition to highlighting the strengths of the program/institution. As part of the NILOA process, the narrative report schools submit contains a growth/improvement plan section that is scored by reviewers and is used to inform the final decision.

These process findings were used to inform the PTEPA Rubric rating and review process. For example, program leaders who are completing the PTEPA Rubric are asked to engage multiple stakeholders in doing so, and completion of the PTEPA Rubric should also include a narrative self-study with a growth/improvement plan (see Chapter 6: "How Can You Use the PTEPA Rubric, and What Do Your Results Mean?"). In addition, APS is encouraged to support PTEPA Rubric completion with webinars and coaching (see Chapter 7: "What Should Come Next?").

SCORING APPROACHES

The PTEPA Rubric and its scoring mechanisms were designed after a brief investigation of similar accreditation processes (particularly HLC, CAEP, ABET, and the Colorado Teacher Quality Standards[1]). Dr. Ribera's post-hoc review provided a broader analysis of accreditation approaches and found that several accreditation bodies take comparable approaches to scoring.

Specifically, in many cases institutions/programs are scored using a descriptive rubric with a three-point scale and an option to identify insufficient evidence or a non-applicable standard. In the case of CAEP, the three-point scale helps to identify standards that are above a sufficient level, at a sufficient level, or below a sufficient level.

In determining excellence in campus-level assessment, NILOA focuses on exemplary rather than sufficient levels using the following three-point scale: "needs significant improvement to meet the exemplary definition," "falls short of exemplary definition," and "meets the exemplary definition." For NILOA, the review committee assigns "excellence" designations based on a weighted sum score determined by reviewers using a multidimensional rubric.

A similar approach is taken among reviewers from the American Council on Education when assessing course quality; they identify three levels of standards—recommended, mandatory, and mandatory minimum standards. Their levels are as follows: (a) recommended standards do not count toward determining credit recommendation eligibility, (b) at least 9 out of 11 mandatory standards must be rated effective or exemplary, and (c) all 7 mandatory minimum standards must be rated effective or exemplary.

An adapted version of the American Council on Education's approach may eventually be an appropriate way for scoring the PTEPA Rubric; for example, perhaps all of the Prevalent components would need to be scored at the Benchmark level in order to meet a standard.

RECOGNITION FOR EXEMPLARY PERFORMANCE

Dr. Ribera investigated how accrediting bodies recognize high-performing schools. The various accrediting bodies simply recognize schools by granting them full accreditation. NILOA recognizes institutions for "excellence" in campus-level assessment. Designees are recognized for exhibiting excellence in assessment or sustained excellence in assessment, which is for institutions that have engaged in meaningful assessment work for more than five years. Excellence in Assessment designees are given a plaque and are recognized in press releases. NILOA provides designees with opportunities to present at scholarly conferences as a way to share best practices in campus-level assessment and support the professional development of assessment professionals. These practices were taken into account when making recommendations to APS as to how best to use PTEPA Rubric results.

ENDNOTES

1 Colorado Teacher Quality Standards, accessed at https://www.cde.state.co.us/educatoreffectiveness/teacherqualitystandardsreferenceguide.

APPENDIX 5

Review of Related Reports: Validation of the PTEPA Rubric Content and Structure

The PTEPA Rubric overlaps with, and is distinct from, other related instruments and reports.

INTRODUCTION

Several reports and instruments informed the PTEPA Rubric. This appendix systematically lists the items and components that comprise the PTEPA Rubric and indicates alignment of these elements with other existing instruments and reports. This is one portion of the validation process, showing how the PTEPA Rubric overlaps with and is distinct from other efforts.

REPORTS AND SOURCES REVIEWED

Below are the resources that were reviewed. Each is preceded by a short title and an abbreviation of that short title, which is used in the table that follows.

- *PhysTEC Key Components* **(KC)**. The Key Components[1] were developed by the PhysTEC project through studies and experience in physics teacher preparation and are a precursor to the PTEPA Rubric.
- *Teacher Education Program Assessment* **(TEPA)**. The TEPA (Coble, 2012) is an instrument to analyze teacher preparation programs and served as an initial framework to develop the PTEPA Rubric.
- *Transforming the Preparation of Physics Teachers: A Call to Action. A Report by the Task Force on Teacher Education in Physics* **(TTEP)**. The TTEP task force was charged with documenting the state of physics teacher preparation and making recommendations for the development of exemplary teacher education programs (see Meltzer, Plisch, and Vokos, 2012). The task force work included identifying features of a set of thriving programs.
- *UTeach Elements of Success* **(UTch)**. The *UTeach Elements of Success*[2] describes the unique and critical components of the UTeach model.
- *National Council on Teacher Quality* **(NCTQ)**. The *Teacher Prep Review* (TPR)[3] evaluates critical areas of teacher preparation using measurable standards that are aligned to state learning standards and best practices, based on expert review and practice.
- *Council for the Accreditation of Educator Preparation* **(CAEP)**. CAEP[4] provides accreditation and program review to various programs (such as departments, schools, and colleges) that prepare teachers and educators. This “seal of approval” ensures quality in educator preparation across disciplinary areas.
- *Various physics career reports* **(CAR)**. Many reports have addressed preparing physics students for diverse careers and creating strong physics programs. Listed in chronological order below, these informed the PTEPA Rubric: *Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP)* (Hilborn, Krane, and Howes, 2003) identified features of thriving physics programs (those with many majors and graduates); *Equipping Physics Majors for the STEM Workforce* (Czujko, Redmond, Saucy, and Olsen, 2014) was a product of the AIP Career Pathways Project, describing how departments can support diverse career pathways; *Phys21: Preparing Physics Students for 21st Century Careers* (Heron and McNeil, 2016) is a more recent report describing the skills and knowledge that physics graduates need and how departments can support these student outcomes are summarized together in table 8.

ALIGNMENT RESULTS

Table 8 demonstrates where the recommendations of each of these reports align with elements in the PTEPA Rubric.

Appendix A6 provides further detail about the literature supporting each PTEPA Rubric component (and several items) as well as a narrative history of the modification of several elements of the rubric.

Table 8. Alignment of the PTEPA Rubric items, components, and standards with relevant reports and sources.

	Description	KC	TEPA	TTEP	UTch	NCTQ	CAEP	CAR
1	**INSTITUTIONAL COMMITMENT**	**x**	**x**	**x**				
1A	**Institutional Climate and Support**		**x**	**x**				**x**
1A-1	University-level support for STEM education							x
1A-2	Institutional mission of teacher education		x	x				
1A-3	Administrative recognition for physics teacher education (PTE) program			x				
1A-4	University-level support for teacher education	x		x				
1A-5	Arts & Sciences (A&S)–level support for teacher education				x			
1A-6	School of Education (SoE)–level support for physics teacher education				x			
1B	**Reward Structure**	**x**	**x**	**x**				
1B-1	Promotion and tenure in physics	x	x	x				
1B-2	Time for PTE program leaders to engage	x	x	x				
1B-3	Recognition for PTE program team		x	x				
1C	**Resources**			**x**	**x**			
1C-1	Engaged staff				x			
1C-2	Institutional funding		x	x	x			
1C-3	External funding		x		x			
1C-4	Stability of program operational funding				x			
1C-5	Program space				x			
2	**LEADERSHIP AND COLLABORATION**	**x**		**x**	**x**			
2A	**Program Team Members**	**x**		**x**	**x**			
2A-1	PTE program leaders	x		x	x			
2A-2	PTE program team	x			x			
2A-3	Teacher in Residence (TIR)	x	x	x	x			
2A-4	Teacher Advisory Group (TAG)	x						
2B	**Program Team Attributes**	**x**			**x**			
2B-1	Common vision among the PTE program team				x			
2B-2	Positional power	x						
2B-3	Disciplinary expertise				x			

Table 8 continued. Alignment of the PTEPA Rubric items, components, and standards with relevant reports and sources.

2B-4	Personal motivation to improve PTE							
2B-5	Integration of Teacher in Residence (TIR)	x	x		x			
2B-6	K–12 school engagement	x	x					
2B-7	Physics Education Research (PER) expertise	x			x			x
2B-8	Professional engagement in PTE							
2B-9	Reputation of PTE program team							
2C	**Program Collaboration**	**x**	**x**	**x**	**x**			**x**
2C-1	Communication across units on PTE program elements			x	x			x
2C-2	Negotiated roles between units		x	x	x			
2C-3	Boundary crossers		x	x				
2C-4	Collaboration with PTE mentor on student teacher placement			x	x	x		
2C-5	Departmental representation			x	x			
2C-6	Curriculum development between units	x		x	x			
2C-7	Collaboration on student advising			x	x			
2C-8	Cohesiveness of student experience							
3	**RECRUITMENT**	**x**		**x**			**x**	**x**
3A	**Recruitment Opportunities**	**x**					**x**	
3A-1	Physics majors	x						x
3A-2	Physics-aligned majors	x						
3A-3	Recruitment network			x				
3A-4	Program identity and reputation				x			
3B	**Recruitment Activities**	**x**		**x**	**x**		**x**	**x**
3B-1	Physics teaching advisor	x		x	x			
3B-2	Physics teaching ambassador	x			x			
3B-3	Accurate information about career benefits of teaching							
3B-4	Program promotion	x		x	x			x
3B-5	Physics climate toward teaching as a career	x		x	x			x
3C	**Early Teaching Experiences for Recruiting Teacher Candidates**	**x**	**x**	**x**	**x**			**x**
3C-1	Attractiveness of early teaching experiences	x		x	x			x
3C-2	Exposure to intellectual challenge of teaching	x						x
3C-3	Availability of early teaching experiences		x	x	x			x
3C-4	Recruitment within early teaching experiences				x			
3C-5	Exposure to K–12 teaching environments	x		x	x			

Table 8 continued. Alignment of the PTEPA Rubric items, components, and standards with relevant reports and sources.

3D	**Streamlined and Accessible Program Options**	**x**			**x**			
3D-1	Streamlined undergraduate teaching track in physics			x				x
3D-2	Time to undergraduate degree plus certification	x		x	x			
3D-3	Post-baccalaureate certification							
3D-4	Certification credits count toward master's degree							
3D-5	Financial support for physics teacher candidates	x	x		x			
4	**KNOWLEDGE AND SKILLS FOR TEACHING PHYSICS**	**x**	**x**	**x**		**x**	**x**	**x**
4A	**Physics Content Knowledge**		**x**		**x**	**x**	**x**	**x**
4A-1	Physics degree for physics teacher candidates		x		x	x		x
4A-2	Introductory physics course pedagogy	x		x				x
4A-3	Student research for teacher candidates		x					x
4B	**Pedagogy Courses and Curriculum**	**x**		**x**		**x**	**x**	
4B-1	Physics pedagogy credits	x		x	x	x		
4B-2	Scientific practices credits			x	x			
4B-3	Science pedagogy course instruction	x		x	x			
4B-4	Science methods instructor expertise				x			
4B-5	Disciplinary context of certification coursework				x	x		
4B-6	Physics microteaching experiences			x				
4B-7	Teaching/Learning Assistant (TA/LA) participation	x						
4C	**Field Experiences in Secondary Physics Teaching**	**x**	**x**	**x**	**x**	**x**	**x**	
4C-1	Number of cooperating physics teachers for field experiences			x			x	
4C-2	Quality of field experiences		x		x		x	
4C-3	Quality of field experience classrooms	x			x		x	
4C-4	Experience with different populations and environments		x		x		x	
4D	**Student Teaching**		**x**		**x**	**x**	**x**	
4D-1	University supervisor collaboration with PTE team		x	x	x	x		
4D-2	University supervisor experience		x	x	x		x	
4D-3	Quality of cooperating teachers for student teaching	x			x	x	x	
4D-4	Number of quality cooperating teachers for student teaching			x			x	
4D-5	Quality of student teaching learning environments				x		x	

Table 8 continued. Alignment of the PTEPA Rubric items, components, and standards with relevant reports and sources.

5	**MENTORING AND PROFESSIONAL SUPPORT**	**X**	**X**	**X**	**X**		**X**	**X**
5A	**Mentoring and Support Toward a Physics Degree**		**X**					**X**
5A-1	Student community in physics		X					X
5A-2	Student advising and career mentoring in physics		X					X
5B	**Mentoring and Support Toward Becoming a Physics Teacher**	**X**	**X**	**X**	**X**		**X**	
5B-1	Advising of physics teacher candidates		X	X	X		X	
5B-2	Mentoring of physics teacher candidates by a PTE mentor	X	X	X	X			
5B-3	Community of physics/STEM teacher candidates				X			
5B-4	Community with in-service teachers			X				
5C	**In-service Mentoring and Professional Community**	**X**	**X**	**X**	**X**			
5C-1	Alumni community	X	X	X	X			
5C-2	PTE mentor for beginning teachers		X	X	X			
5C-3	Professional development for in-service teachers	X	X	X	X			
6	**PROGRAM ASSESSMENT**	**X**	**X**		**X**		**X**	
6A	**Program Outcomes**		**X**		**X**			
6A-1	Annual graduation from PTE program		X					
6A-2	Annual recruitment in PTE program		X					
6A-3	Diversity of physics teacher candidates		X			X	X	
6A-4	Career persistence	X	X					
6B	**Program Evaluation and Improvement**	**X**	**X**		**X**	**X**	**X**	
6B-1	Tracking program metrics		X		X	X	X	
6B-2	Feedback from stakeholders				X	X	X	
6B-3	Assessing learning outcomes	X			X	X	X	
6B-4	Program improvement from feedback and program data		X		X	X	X	
6C	**Communication to Stakeholders**		**X**		**X**		**X**	
6C-1	Communication within the university				X			
6C-2	Communication with university administrators				X			
6C-3	Publicity and advocacy		X		X			
6C-4	Scholarly work							

ENDNOTES

1 Retrieved online at http://phystec.org/keycomponents.

2 Retrieved online at https://institute.uteach.utexas.edu/uteach-elements-success.

3 NCTQ "Teacher Prep Review Standards and Indicators"; accessed online at https://www.nctq.org/dmsView/NCTQ_-_Standards_and_Indicators_-_Traditional_Programs.

4 See http://ncate.org. We particularly referred to the *Readiness for Accreditation Self-Assessment Checklist* at http://www.ncate.org/accreditation/caep-accreditation/application and the *CAEP Accreditation Handbook* at http://www.ncate.org/accreditation/caep-accreditation/caep-accreditation-handbook.

APPENDIX 6

Item History: Validation of Individual PTEPA Rubric Items

This section shows results for all individual items and describes some of the key decisions made during the development of the PTEPA Rubric based on literature, case studies, and expert feedback.

INTRODUCTION

The PTEPA Rubric was subjected to a variety of forms of validation, as described in Chapter 2. This section provides a descriptive narrative of the validation of the instrument and is not intended to be exhaustive. Here we show results from individual items and document some of the central decisions and substantive supports from the literature without describing every decision that was made or the literature supporting every item. We acknowledge the significant contribution of Wendy Adams (Colorado School of Mines) to the literature review and development of several PTEPA Rubric items and Justyna P. Zwolak (Joint Center for Quantum Information and Computer Science) for helping us organize our item history.

INDIVIDUAL ITEM RESULTS

Figure 17 shows the results across programs for each of the PTEPA Rubric items. This data can serve as a reference for other programs and demonstrates that at least some programs are strongly rated on each PTEPA Rubric item (particularly the Prevalent items).

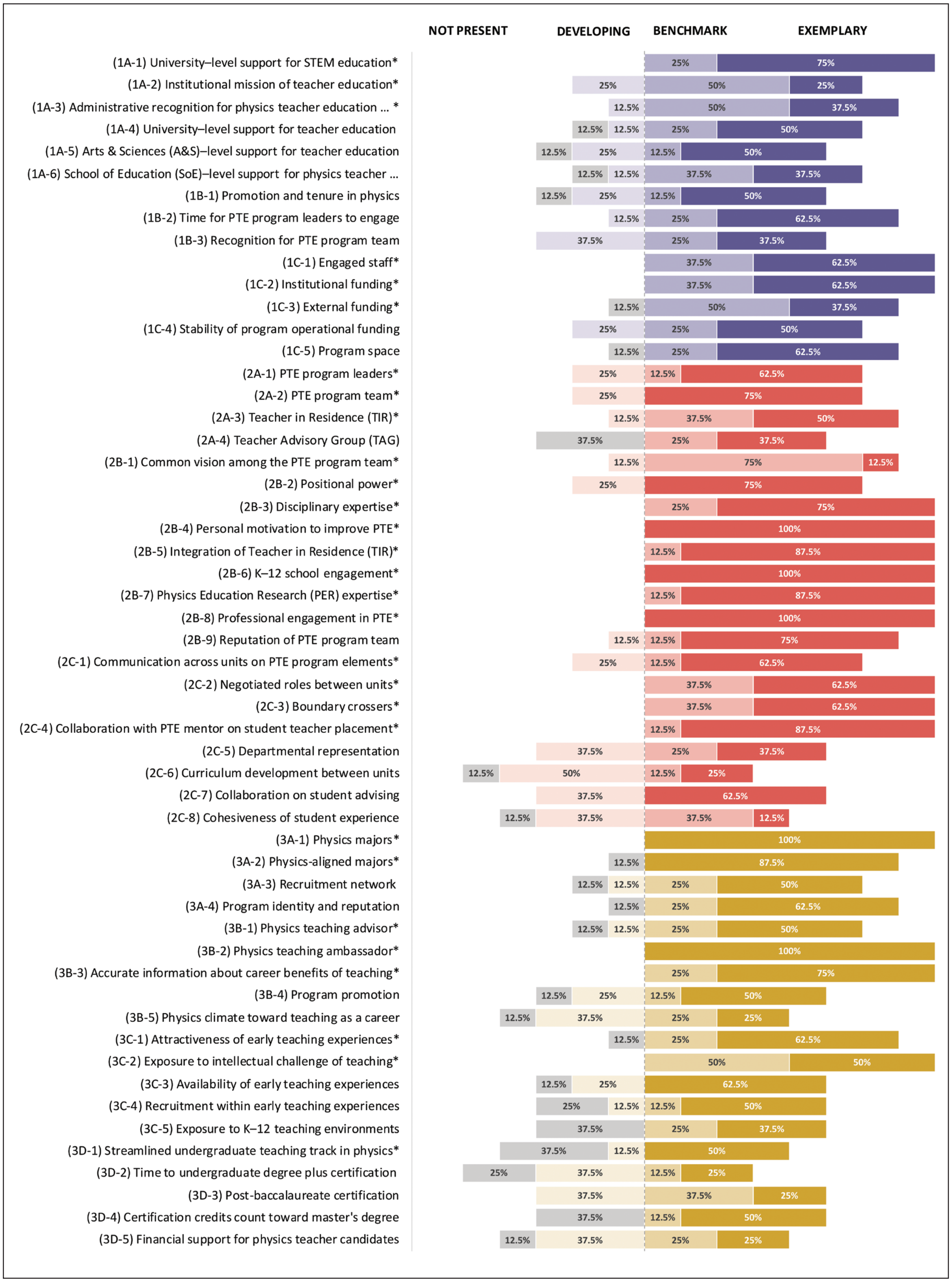
STANDARD 1: INSTITUTIONAL COMMITMENT

For this standard, we needed to clearly define "physics teacher education (PTE) program." Before this definition was created, there were some discrepancies among programs on what was included. By defining the program as a formal named program (or as the collection of program elements directly serving physics teachers), we didn't force formal programs (such as UTeach) to draw somewhat artificial divisions within their programs but ensured that institutions were not given credit for supporting only a general teacher licensure program.

1A: Institutional Climate and Support

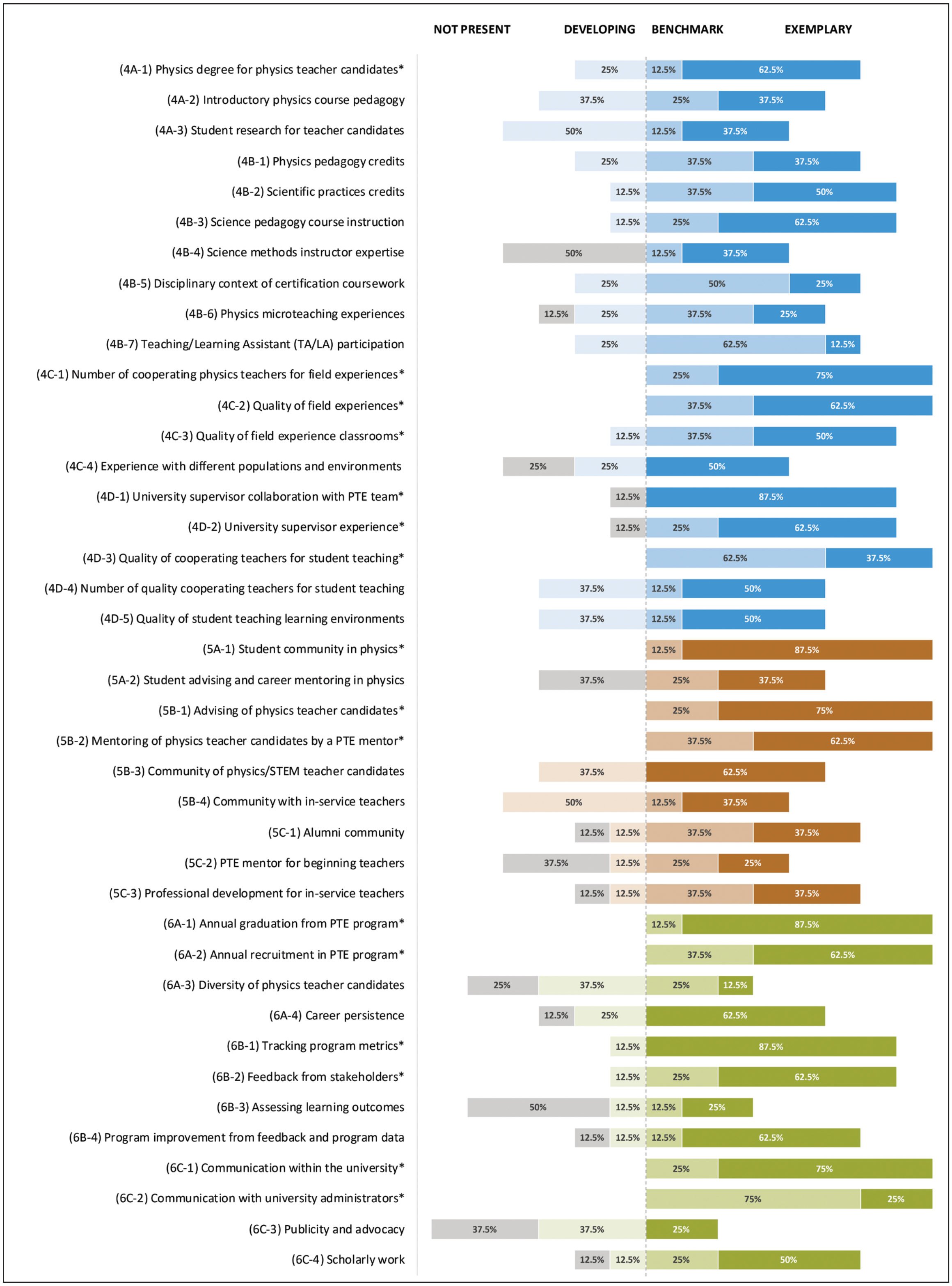
- **"University-level support for STEM education"** is often cited as being an important element of teacher production (e.g., Scherr, Plisch, and Goertzen, 2017; Vokos and Hodapp, 2015). We originally tried to write these items to describe "institutional culture" (Kezar, 2014), such as norms and practices around teacher education in different units, but such items proved difficult to assess reliably. In general, this was a difficult area for which to write reliable items. For example, if the school of education has a licensure program, is this evidence of institutional support for teacher education? Eventually, we settled on separating out institutional support at the university level or within either the College of Arts and Sciences or school of education and measuring different levels of observable support.
- **"Institutional mission of teacher education"** (and alignment of a change strategy with that mission) is a critical consideration during a change process (see for example Kezar, 2014; National Research Council, 2013; Vokos and Hodapp, 2015). In the case of teacher preparation, an institution may have an explicit mandate to prepare future teachers, a history of service, or a strong culture of STEM educational improvements.

Figure 17: Results of PTEPA Rubric items.



Percentage of PTEPA Rubric items that were rated Not Present, Developing, Benchmark, and Exemplary at the studied programs. Prevalent items are indicated with an asterisk.

Figure 17 continued: Results of PTEPA Rubric items.



1B: Reward Structure

- **"Time for physics teacher education (PTE) program leaders to engage"** was indicated by experts as well as Vokos and Hodapp (2015) as an important element apart from promotion or awards. This item may help account for the success of programs that are run out of a school of education (or equivalent) where physics teacher education is often part of regular duties. We chose not to have separate items for leaders in physics and education (for which there might be different expectations of engagement in teacher education) since what ultimately matters is that leaders significantly engage in the work regardless of their department.
- **"Recognition for PTE program team"** is discussed in several resources as an important element of support for physics teacher education (e.g., National Research Council, 2014; Vokos and Hodapp, 2015). We determined that recognition for the *program* as a whole is an element of institutional support (in *1A: Institutional Climate and Support*, above) but that recognition for the *team* provides the reward and recognition needed to support the program leaders.

1C: Resources

This component was developed after we realized that several items, such as funding, space, and staff, broadly supported the program. We collected these items into this single component within the **Institutional Commitment** standard.

- **"Engaged staff"** was observed to be an element that deepens the impact of a (typically busy) program leader's efforts. Such staff could be in a named position (such as program coordinator; discussed in Meltzer, Plisch, and Vokos, 2012), administrative staff, or a Teacher in Residence (TIR); regardless, such personnel are resources for the program. To avoid double-counting TIRs, the physics background of a TIR is explicitly included in **Standard 2: Leadership and Collaboration**, but not in this item.
- **"Institutional funding"** went through several rounds of clarification, resulting in a detailed footnote about what does and doesn't count as institutional funding. We felt that a faculty member's service commitment should not be counted, as this is not an indication of a strong financial resource (most faculty members exceed their service requirements). Faculty members' salaries beyond normal duties, however, did seem an acceptable financial resource to include. While regional variations in salary may affect the amount allocated to this item, the levels of funding outlined provided a broad enough range to capture greatly different levels of financial resources. Scherr, Plisch, and Goertzen (2017) describe a wide variety of funded activities in addition to salary that could support PTE, including Learning Assistantships or similar programs, scholarships, faculty time to design certification programs, pre-service teacher advising, induction programs, professional development programs for in-service teachers, creation of physics pedagogy courses, Teacher Advisory Groups, Teachers in Residence, or development of resources for PTE; these were used to generate the list of example activities in the footnote on that item.
- **"Stability of program operational funding"** originally included separate items for internal and external funding; we determined that stability of funding (regardless of the source) was the essential element to measure. We defined stability as relating to operational funding (rather than all funding) because grants may fund activities or personnel that are useful but not absolutely required (such as additional LAs). There is much variability among programs as to what is required for success, and so we allowed program leaders to determine what would be included in operational funding.
- **"Program space"** provides visibility for a program and an opportunity to form community (as in Hilborn, Krane, and Howe, 2003 and Czujko et al., 2014). For brevity, we included the location of the space at the top level of this item (rather than as a separate item). We originally counted whether the program was housed in a *central* location, but we modified this language since a central location may or may not be visible to physics or natural science students. The Exemplary level instead asks whether it is in an area frequented by physics students; if that is the case, the space is more likely to create a stable community among physics teacher candidates and serve as a recruitment mechanism.

Items Removed

- **"Special organizational structures"** (such as STEM institutes) was an item on the TEPA, but we found that the contribution of such structures to PTE was unclear.
- **"Program longevity and reputation"** was included as a resource that helps the program advocate for other resources, creates a favorable climate for student recruitment, and creates a pool of local teachers for field experiences. This item was moved to **Standard 3: Recruitment** as an element of program reputation.
- **"Program autonomy"** was included as a resource based on the fact that UTeach functions as separate academic unit, allowing the program to control budget and staff. However, in some cases this autonomy could be a liability for a program, taking up program leaders' time, and so was removed.

STANDARD 2: LEADERSHIP AND COLLABORATION

For this standard, we needed to clearly define "program leaders" and "program team." For example, should faculty who teach courses for future physics teachers be included on the program team? Many program leaders wanted to give due credit to such people, who are an essential part of the PTE program. By defining "program leaders" as those who spearhead the program and advocate for resources and "program team" as others responsible for the daily operation of the program, we provided a clearer delineation between the types of people who may be involved in the program, thus enhancing reliability. As part of the PTEPA Rubric documentation, we require the person completing the instrument to name the program leaders, the program team, the academic unit out of which the PTE program operates, and other academic units with which the PTE program collaborates. This is intended to ensure that these people and units are consistently and explicitly referred to when completing the instrument.

2A: Program Team Members

Overall this component counts the number of people involved in different roles, while *2B: Program Team Attributes* describes their characteristics.

- **"PTE program leaders."** PhysTEC sites that sustained their activities included both a champion and a team as described in Scherr, Plisch, and Goertzen (2017). That report defines a champion as one who "secures funding and personnel benefiting physics teacher education and negotiates with the institution for changes beneficial to physics teacher education." We used this definition of "champion" to generate our definition of "program leaders," but we changed the name of the position as we felt that "champion" suggested a single leader. The definition originally indicated that the program leader was "in charge" of daily operation of the program, but this was removed because program leaders did not feel that this was universally true of them.
- **"PTE program team."** During visits, we found that program leaders typically worked with several others who did not rise to the level of "leader" but were also important for success of the initiative (such as course instructors, LA coordinators, or advisors). Kezar (2014) notes that successful change initiatives are those that include a leadership team rather than a solo leader, substantiating our choice of scale points for "program leaders" and our inclusion of "program team" as an item.
- **"Teacher in Residence (TIR)."** A TIR is an important element of the PhysTEC model (Plisch, Blickenstaff, and Anderson, 2015) and important for sustainability of such efforts (Scherr, Plisch, and Goertzen, 2017). Both the disciplinary expertise of the TIR (to provide physics-specific mentoring) and the full time equivalent (FTE; to allow them to fully support students) are important, and so we included these as two dimensions within a single item. In our program visits, we noted that the more TIRs there were, the more productive roles they were able to fill; we used "FTE" instead of "full time" to acknowledge that multiple part-time TIRs may be able to be used to fully staff positions. Given the focus of the PTEPA Rubric on physics teacher preparation, we felt that a science TIR would not adequately fulfill the role, regardless of their FTE.
- **"Teacher Advisory Group (TAG)"** was included as an item, as TAGs are listed in the PhysTEC Key Components as another way to gain insight for program design from working teachers.

2B: Program Team Attributes

- **"Common vision among the PTE program team"** was included after expert reviewers commented that such unity is important in a team. Inclusion of this item is supported by the institutional change literature (Kezar, 2014); successful change initiatives are characterized by collective vision that creates a sense of identity, which drives the initiative. Kezar also notes that collective vision is particularly important for *teams* or groups (as opposed to individuals), as teams need a shared sense of purpose and meaning for the initiative. This suggests that it is likely acceptable to rate a single leader as Exemplary on this item.
- **"Positional power"** is important for leaders of a change initiative (Kezar, 2014), as leaders in positions of authority are able to allocate funding and resources, motivate personnel through incentives and rewards, and hire and train employees.
- **"Disciplinary expertise"** captures the importance of having both disciplinary and pedagogical expertise on the team. While many reports refer to the importance of having collaborators in physics and education (e.g., Meltzer, Plisch, and Vokos, 2012), we observed solo program leaders who encapsulated both types of knowledge in a single person (our Benchmark level). We also noted that programs that had people in both departments or serving as a bridge between departments played a specific role in project collaboration and communication in addition to providing relevant expertise. Thus, we differentiated between "Disciplinary expertise" (this item), "Boundary crossers," and "Departmental representation" (both in *2C: Program Collaboration*).
- **"Integration of Teacher in Residence (TIR)"** was included due to the many roles that may be productively filled by a TIR, and we observed that programs varied widely in the degree to which the TIR was leveraged in these ways. For example, Plisch, Blickenstaff, and Anderson (2015) note that TIRs may fill roles in recruiting, advising, mentoring, teaching, curriculum development,

coordinating Learning Assistants, providing professional development, serving as ambassadors to local schools, and supporting professional communities (see the appendix within that publication for a complete list of possible TIR activities).

- **"K–12 school engagement"** was included based on an original item, "K–12 school interactions," from the TEPA instrument (Coble, 2012). The spirit of the item is that programs need to be grounded in the reality of K–12 classrooms and their needs. The word "regularly" was added so that "regular engagement" was required for Benchmark; if a program leader visited a K–12 school five years ago, this would thus not be counted.
- **"Physics Education Research (PER) expertise"** originally indicated whether the program included a physics education *researcher* but was modified after expert review to focus more on physics education research *consumers*, as researchers may or may not be focused on or knowledgeable about teacher preparation. Use of PER in instruction is included in the Benchmark level to differentiate those who know what PER means from those who use it in practice.
- **"Reputation of PTE program team"** was included because a strong reputation can be leveraged to argue for resources. This was observed at several programs that were led by a faculty member with a strong reputation; administrators would sometimes support the PTE program in order to keep that faculty member at the institution. The Exemplary level of the item was changed from "national reputation" to measuring a local record of leading change as this was deemed more immediately important to garnering resources for the program.

2C: Program Collaboration

The importance of collaboration between academic units is documented in several reports (Vokos and Hodapp, 2015; Meltzer, Plisch, and Vokos, 2012). The specific items in this component were largely developed anew for the PTEPA Rubric (with the assistance of Wendy Adams) with the aim of describing the possible intersection points between physics and education and characterizing the health of that intersection. While there is some overlap among the types of things measured in this component and other standards (such as student teaching or advising), the items in this component explicitly describe the *collaboration* on this element as the dimension of interest. We explicitly defined collaboration as between the program and relevant units (wherever the program is housed) to allow for the diversity of programs observed (i.e., some are run through the physics department and some through the school of education).

- **"Communication across units on PTE program elements."** The T-TEP report (Meltzer, Plisch, and Vokos, 2012) discusses the importance of having contacts, mutual awareness, and meetings between units.
- **"Negotiated roles between units"** was included based on an original item from the TEPA instrument (Coble, 2012). This item was iterated a good deal over time. For example, it originally included whether there were written agreements between units, but this was never observed, and so the scale points were modified to better describe observed practices. The Exemplary level was informed by the UTeach model at the University of Texas at Austin, where dean-level collaboration and strategic oversight were important elements.
- **"Boundary crossers"** counts personnel who provide bridges between departments and are noted as useful touchpoints for collaboration in Vokos and Hodapp (2015). This is distinct from "Departmental representation," which counts whether the program team has members in each collaborating department.
- **"Collaboration with PTE mentor on student teacher placement"** was included because we observed a wide variety of practices with physics teacher candidates placed solely by a teacher education office staff member, which differs from personalized and careful placement of teacher candidates with specific program graduates so as to match their needs.
- **"Curriculum development between units"** is an important element of collaboration (Vokos and Hodapp, 2015), as it can help create a streamlined degree plan (see *3D: Streamlined and Accessible Program Options*) and/or pedagogy courses with adequate physics content included (see *4B: Pedagogy Courses and Curriculum*).
- **"Collaboration on student advising"** originally allowed co-advising in physics and education to serve as the Benchmark level, but expert review noted that this could be a potentially harmful situation since there may not be good coordination between the units. The item was revised.

Items Removed

- **"Advocacy."** We originally included an item about whether program leaders engaged in advocacy, as this has been identified as an important element in teacher preparation (Scherr, Plisch, and Goertzen, 2017; Kezar, 2014). However, the main contribution of advocacy did not align well with the goal of Standard 2 ("an effective leadership team"). Advocacy was included instead in Standard 6 as an element of communication to stakeholders.

- **“Collaborators”** was originally an item discussing who the program team collaborated with in other academic units. Once the *2C: Program Collaboration* component was added and the program team and leaders were defined, this item was redundant.
- **“Physics Teacher Education program position”** was an item describing whether there was a named position (such as “program coordinator”), as advocated in Meltzer, Plisch, and Vokos (2012). This was removed because it was unclear just what the importance of a named position might be. Some program leaders held such a title and others did not, and it was unclear that there was any effect of this designation.
- **“Course instruction by content experts”** was an item that asked whether physics faculty teach pedagogy courses. This was removed as it seemed a less critical element of collaboration; the disciplinary expertise of the pedagogy course instructor is included in *4B: Pedagogy Courses and Curriculum*.
- **“Student teaching experience”** asked whether a *physics* faculty member observed and provided feedback during student teaching. Since such a situation was deemed to be relatively rare, this item was removed in favor of asking about disciplinary expertise of the university supervisor within *4D: Student Teaching*.

STANDARD 3: RECRUITMENT

The **Recruitment** standard was created relatively late in PTEPA Rubric development. In early versions of the PTEPA Rubric, we had a standard called “Physics Program,” which counted items related to thriving physics programs (e.g., Hilborn, Krane, and Howes, 2003), such as number of majors, diversity within the major, department teaching practices, student community, and climate toward teaching. However, we realized that these items had different types of influences, such as recruitment, content knowledge, or retention of physics teacher candidates. While it was convenient to have a standard directly addressing the physics program, we made a strategic decision to redistribute the items related to the physics program into the standards that they affect, making their influences and expected outcomes more clear. The final **Recruitment** standard thus only includes elements of the physics program that are likely to impact recruitment. We note that there are some other items related to physics program quality, such as advising and student community in the department, quality of the introductory course, and availability of student research opportunities; these arguably have influences on recruiting students to diverse careers and the major (e.g., Hilborn, Krane, and Howes, 2003; Seymour and Hewitt, 1997; Czujko, Redmond, Sauncy, and Olsen, 2014), but we chose to place those in other standards where they have more influence (i.e., **Standard 4: Knowledge and Skills for Teaching Physics** and **Standard 5: Mentoring and Professional Support**).

3A: Recruitment Opportunities

- **“Physics majors”** is calculated compared to national quartiles, as derived from American Institute of Physics data (Mulvey, Tyler, Nicholson, and Ivie, 2017). This resulted in the following quartiles for majors in B.A./B.S. programs and PhD programs:

	B.A./B.S.	PhD
1st quartile	0–2	0–7
2nd quartile	3–4	8–13
3rd quartile	5–8	14–24
4th quartile	9+	25+

- **“Physics-aligned majors”** was originally worded in terms of numbers of majors, but it was changed to the size of the pool to better count the available students for recruitment. It has been suggested that this item could be defined and counted using data from the Integrated Postsecondary Data System (IPEDS).
- **“Recruitment network”** was included per the T-TEP report (Meltzer, Plisch, and Vokos, 2012). A noted challenge with this item is that it is very context dependent. If there is an engineering teaching program, for example, it would likely not make sense for engineering units to refer their students to another program.
- **“Program identity and reputation”** is a combination of two items for the sake of brevity, “Program reputation” and “Program identity,” which were originally within *1C: Resources.* Since an institution can’t necessarily *create* a strong PTE program identity or reputation, these items felt more appropriate in **Standard 3: Recruitment** than in **Standard 1: Institutional Commitment.** We originally included a measure of whether the program was nationally known, but we removed this since it doesn’t support local recruitment. We also originally included discussion of the level of local awareness of the program but found this overly complicated the item.

3B: Recruitment Activities

- **"Physics teaching advisor"** reflects the importance of having some recruitment in the physics department (Vokos and Hodapp, 2015), departmental support for teaching careers (Marder, Brown, and Plisch, 2017), and strong advising for diverse career options (Hilborn, Krane, and Howes, 2003).
- **"Physics teaching ambassador"** counts whether there is a positive role model for teaching. This might be the faculty member who actively recruits students to the profession (e.g., "You know, I think you would make a great teacher," Vokos and Hodapp, 2015), which was observed within several programs, or a TIR who interacts with LAs or students in introductory courses. Originally this item was written to reflect a TIR role only, and thus K–12 experience was required, but this seemed to set too high of a bar, and so K–12 experience was reserved for the Exemplary level.
- **"Accurate information about career benefits of teaching"** is cited as particularly critical for teacher recruitment based on documented misconceptions (Marder, Brown, and Plisch, 2017; Adams, 2017). The scale points were developed in collaboration with Wendy Adams, who is actively researching this area. The item originally counted whether tangible or intangible benefits were included, but that proved confusing and wordy; to better count what programs ought to do that they probably *don't* already do, we focused on financial compensation (which has been shown to be particularly attractive to students; Marder, Brown, and Plisch, 2017) and addressing misconceptions about the profession.
- **"Program promotion"** is the final iteration of two items measuring program marketing (which felt too narrow of a framing) and promotion within courses (such as introductory courses or inclusion in career seminars). The item was also revised to be directed specifically at physics teacher recruitment rather than general teacher recruitment (which often happens within the school of education and may not affect potential physics teacher candidates). While it is important that recruitment occur within the physics department (Vokos and Hodapp, 2015), we found that it was more flexible to word the item generally because PTE programs are housed in a variety of units.
- **"Physics climate toward teaching as a career"** is supported as an item by multiple career-focused reports. *SPIN-UP* (Hilborn, Krane, and Howes, 2003) notes that strong physics programs expose students to diverse career paths and don't treat those not intending to pursue graduate study in the discipline as second-class citizens. The *Career Pathways* report (Czujko, Redmond, Sauncy, and Olsen, 2014) similarly notes that faculty commitment to majors at all levels is a critical part of career preparation. The T-TEP report (Meltzer, Plisch, and Vokos, 2012) emphasizes the importance of a welcoming and encouraging environment in the department toward teaching in addition to faculty encouragement to pursue teaching careers. We removed a scale point indicating whether faculty valued student learning (for undergraduates), as that was not necessarily related to valuing teaching as a profession for students.

3C: Early Teaching Experiences for Recruiting Teacher Candidates

The importance of early teaching experiences (such as Learning Assistant programs) for drawing students into teaching is substantiated in many reports (e.g., Vokos and Hodapp, 2015; Sandifer and Brewe, 2015). In this component, we outlined the possible dimensions of such teaching experiences. Early teaching experiences can also prepare students pedagogically; that is separately counted in *4B: Pedagogy Courses and Curriculum* in terms of the number of teacher candidates who engage in early teaching experiences.

- **"Exposure to intellectual challenge of teaching"** is an important element of early teaching experiences (Vokos and Hodapp, 2015; Marder, Plisch, and Vokos, 2017), as such challenge tends to attract students to the teaching profession. This item and "Attractiveness of early teaching experiences" replaced an earlier item that attempted to measure the *quality* of early teaching experiences.
- **"Exposure to K–12 teaching environments"** was included to reflect the excitement for teaching, which can come from being exposed to the environment in which you will be teaching. Fourth grade was chosen as the lowest level since this is the level at which physical science is introduced, and elementary classrooms can be particularly energizing (despite the fact that this is not the grade level at which physics teachers would be licensed).

3D: Streamlined and Accessible Program Options

- **"Streamlined undergraduate teaching track in physics"** is cited as important for recruitment to the profession (Heron and McNeil, 2016; Palmquist and Jackson, 2015). Other reports cite the flexibility of the degree requirements or having multiple degree options as important for career preparation (e.g., Hilborn, Krane, and Howes, 2003; Czujko, Redmond, Sauncy, and Olsen, 2014). Multiple degree tracks also communicate the departmental commitment to diverse career paths.

- **"Time to undergraduate degree plus certification"** is included due to the influence of degree length (and associated financial burden) on teacher recruitment; several reports recommend providing an option for certification concurrent with a bachelor's degree in science and reducing the time to degree (National Academy of Science, 2007; Marder, Brown, and Plisch, 2017). That said, it could be argued that a reduced time to degree also reduces the strength of teacher preparation. A controversial[1] report (Levine, 2006) indicates that five-year teacher preparation should be the norm, given the length of time required to achieve a major in the subject area. The levels chosen for this item primarily reflect PhysTEC's recommendations for length of degree.

Items Removed

- **"Local program graduates"** was originally included, counting how many program graduates are teaching in the local area and are thus available to recruit their own students to teaching careers. We removed this item since the number of local graduates is such a strong co-variate with already having a thriving PTE program.
- **"Quality of introductory course"** was originally part of this standard due to its influence on students' perception of teaching careers, but it was moved to **Standard 4: Knowledge and Skills for Teaching Physics** due to its central influence there.
- **"Support for physics teaching improvements"** was an item describing the climate in the physics department for making changes to their teaching. While this is an element of a strong physics program, we felt that the quality of the introductory course was a more direct influence on potential teacher candidates.
- **"Exposure to non-academic careers in physics"** was originally included due to the multiple reports indicating this is an important part of career preparation (Heron and McNeil, 2016; Czujko, Redmond, Sauncy, and Olsen, 2014), but experts indicated that such exposure is not necessarily correlated with *teacher* recruitment, and so only items related to teaching as a career were maintained.
- **"Exposure to teaching as a career"** was an item directly assessing whether there is a career seminar or discussion of teaching in introductory courses as one element of such a positive climate for teaching; for brevity, this was incorporated into "Program promotion" as one possible practice among many.
- **"Mission for teacher preparation."** We removed this item measuring whether the physics department felt that preparing teachers was part of their mission (Meltzer, Plisch, and Vokos, 2012), as this proved difficult to assess.

STANDARD 4: KNOWLEDGE AND SKILLS FOR TEACHING PHYSICS

This standard has undergone the most revision over time due to the multitude of skills and knowledge required for effective teaching in physics and pedagogy (Etkina, 2010). This standard does not directly address whether teachers attain general pedagogical knowledge (other than physics pedagogical knowledge) or other preparation to teach (such as classroom management), as those are considered the domain of the school of education. Also, the PTEPA Rubric tends to be agnostic on the Next Generation Science Standards (NGSS); we note alignment where appropriate, but the PTEPA Rubric was not directly designed to align with NGSS. The PTEPA Rubric is also more deeply concerned with teacher recruitment and graduation (rather than teacher learning) in order to narrow the scope of the instrument. While expert review suggested many possible improvements to this standard (e.g., measuring whether teachers are prepared to anticipate student thinking or to select and sequence learning experiences and assessments), we determined that this was better relegated to other instruments specific to teacher learning.

4A: Physics Content Knowledge

Several items that were originally in a separate standard related to the physics program were included here as part of the content knowledge required for a teaching license.

- **"Physics degree for physics teacher candidates."** For science teachers to be effective, they require a deep foundation of facts and concepts within the discipline (National Research Council, 1999; Hill and Ball, 2009; Darling-Hammond, 2006b; Grossman, Schoenfeld, and Lee, 2005), and this content preparation may be as important as pedagogical training (White, Presly, and DeAngelis, 2008). The Secondary Sciences Standard for the National Council on Teacher Quality (NCTQ)[2] recommends that single-subject certification require a major (consisting of 30 or more semester credit hours) in that discipline, which aligns with our Exemplary level. A minor in physics is considered Benchmark, as it matches PhysTEC's definition of a secondary graduate,[3] is aligned with the T-TEP policy statement[4] (which recommends a major or a minor), and allows more flexibility for the range of programs, such as general science certification.[5] Note however, that NCTQ also argues that single-subject licensure is preferable; while broad field licensure is flexible for a local district, it creates a shortage of teachers with strong STEM backgrounds. It has been a challenge in general for the PTEPA Rubric to properly give credit for institutions with general science certification.

- **"Introductory physics course pedagogy"** is an important element of preparing students with strong content knowledge (Aguirre et al., 2013; Hilborn, Krane, and Howes, 2003; Heron and McNeil, 2016; Meltzer, Plisch, and Vokos, 2012; National Research Council, 2015); for teacher candidates, it also likely plays a dual role for recruitment to the teaching profession by providing a strong model (Palmquist and Jackson, 2015).
- **"Student research for teacher candidates"** was included due to the many reports indicating the importance of such experiences for learning science content and for understanding the process of science (e.g., Aguirre et al., 2013; Hilborn, Krane, and Howes, 2003; Heron and McNeil, 2015; Sandifer and Brewe, 2015). While undergraduate research is important for the strength of the physics department and degree as a whole, we decided that the important element for the PTEPA Rubric was whether *teacher* candidates participated in these experiences (especially since some observed programs did not support undergraduate research for those in the teacher track). Such research experiences are emphasized among the recommendations for exemplary programs in the T-TEP policy statement[4] and Palmquist and Jackson (2015).

4B: Pedagogy Courses and Curriculum

- **"Physics pedagogy credits"** reflects the strong consensus of the importance of physics-specific pedagogy (Vokos and Hodapp, 2015; Meltzer, Plisch, and Vokos, 2012). The number of credits reflects the range of practices observed and the fact that less than a full course of physics pedagogy is likely more than what most programs offer but is not quite sufficient. Benchmark level would be met by a program that offers a physics pedagogy course, and candidates may also take a one-credit seminar (often as an LA). This level is aligned with recommendations from the NCTQ, which recommends three credit hours of a subject-specific methods course.[6] Note that the T-TEP policy statement[4] suggests that exemplary preparation includes multiple pedagogy courses, as reflected in our Exemplary level. We do allow physics pedagogy to be included if it is part of a general methods course because this is often the case at programs that offer only general science licensure; however, this is at odds with the NCTQ, which does not allow a general methods course to count. We do acknowledge that it is weaker to include pedagogy within a general methods course, but we were unable to write separate PTEPA Rubric items that adequately captured such distinctions succinctly. For example, earlier versions of this element included items for number of science pedagogy credits, physics pedagogy content within the science pedagogy course, and whether science pedagogy was a requirement.
- **"Scientific practices credits"** captures a suggested alignment with NGSS; the item was worded in terms of science (rather than physics) since NGSS suggests that such practices do not need to be within the discipline. We used "credits within the curriculum" due to the diverse ways that such practices may be included (e.g., a standalone research methods or scientific practices course, a portion of a general methods course, or an aspect of a course like Physics by Inquiry).
- **"Science pedagogy course instruction"** reflects the importance of an inquiry-driven curriculum, which has been shown to be related to an increased tendency to develop inquiry-oriented lesson plans and to teach in a way that mirrors scientific practices (Schwartz, 2009).
- **"Science methods instructor expertise"** reflects the importance of having the methods or pedagogy course taught by people with knowledge of physics and with high school experience (recommended by the T-TEP policy statement[4]). In many programs, we noted that a general science methods course taught by such an individual resulted in better preparation of the physics teacher candidates in that course. The lowest level of this item includes physics teaching experience since this is not the norm (many school of education faculty members do not have physics teaching experience). To this, the Benchmark level adds 7th–12th grade experience (rather than general K–12 experience) to ensure that the experience matches the level that teacher candidates are being prepared to teach. Physics Education Research expertise was originally included at the top level, but this was determined to not be as relevant (though it is common among the physics faculty who may teach pedagogy courses).
- **"Physics microteaching experiences"** reflects the value of peer teaching experiences for learning and practicing pedagogy (Etkina, 2010). This item was placed here rather than in *Component 4C: Field Experiences in Secondary Physics Teaching* because microteaching occurs within an undergraduate context and thus doesn't represent a school teaching experience. This decision aligns with the NCTQ Secondary Methods standard,[2] which excludes peer teaching from field practice.

4C and 4D: Field Experiences and Student Teaching

These two components changed significantly over time. Originally, a single component concerning experiential learning opportunities was included, which encompassed learning assistant programs, microteaching, field experiences, and student teaching. This organization lacked focus and was eventually split into the current structure, with *Component 4D: Student Teaching* specifically focusing on items that allow measurement of aspects of the student teaching experience that prepare future teachers to teach physics well. The importance of field experiences and student teaching is well substantiated. Darling-Hammond (2006a) argue that strong, effective teacher education programs include coherent courses, integration between courses and clinical work in schools, and extensive and tightly supervised clinical work connecting theory and practice. The NCTQ Secondary Methods standard[2] recommends practical teaching experience in the discipline before student teaching as well as high-quality student teaching experiences,[7] and the T-TEP policy statement[4] recommends that programs offer physics-specific teaching experiences. The current "field experiences" definition also matches that used in UTeach: opportunities that place students directly within the classroom before student teaching (practicum courses that include observation but not teaching practice do not count).

- **"Number of cooperating teachers"** (both for field experiences and student teaching) was included because many programs lack adequate cooperating teachers. Early versions included whether or not cooperating teachers are "over-used," but this proved difficult to measure.
- **"Quality of cooperating teachers for student teaching"** is worded to be somewhat in line with NCTQ's Student Teaching standard,[7] reflecting the importance of teachers who are effective instructors *and* mentors (Cochran-Smith et al., 2015; Boyd et al., 2009), as well as adding our desired emphasis on level of experience in teaching physics.

Items Removed:

- **"Inquiry in course labs"** was originally included as an item (as in the biology rubrics described in Aguirre et al., 2013). While lab courses are important for career preparation and content learning (e.g., Heron and McNeil, 2015), we determined that the mentored research experience provided more opportunity for understanding the research process (as in the NGSS) and thus is important for future teachers.
- **"Curricular consistency."** Strong, effective teacher education programs (Darling-Hammond, 2006a) include coherent courses and integration between courses and clinical work (e.g., field experiences and teacher production). Thus, earlier versions of the instrument included an item measuring curricular consistency (with levels such as "coursework is somewhat consistent and aligned across the curriculum" and "coursework and experiential learning opportunities are consistent and aligned"). We found that this was too difficult to assess reliably, despite its importance.
- **"Teacher in Residence"** was originally a component of this standard due to its critical importance for pedagogical preparation, but it was moved to Standard 2.
- **"University supervisor observation frequency"** was an item measuring the frequency with which university supervisors observed and gave feedback to students during student teaching due to the importance of this activity in teacher preparation (e.g., Rose and Church, 1998; Darling-Hammond, 2006a; also included in NCTQ standards[7]). This was removed as it was considered to be part of the overall structure of student teaching at the university and thus in the domain of the school of education.
- **"Inquiry-based physics course"** was originally included as an item within *Component 4A: Physics Content Knowledge*, given the importance of such courses for re-learning physics content from an inquiry perspective (as well as modeling physics content). We found that interpretation of this item was not consistent (e.g., many program leaders with a reformed introductory course considered that it was inquiry based, but the item was intended to capture investigation-based courses such as Physics by Inquiry), and it was only an important item within two observed programs. Thus, such courses were instead included as just one possible way to accumulate physics pedagogy credits.

STANDARD 5: MENTORING AND PROFESSIONAL SUPPORT

5A: Mentoring and Support Toward a Physics Degree

This component includes several elements that were originally in a separate component dedicated to measuring elements of strong physics programs. That separate physics program–specific component was since removed, and its items were redistributed into other standards and components where they had the most direct impact.

- **"Student community in physics"** is indicated as an important element of a strong physics program that retains diverse students in the degree program and includes elements such as a physics club, student organizations, and a student lounge (Hilborn, Krane, and Howes, 2003; Heron and McNeil, 2016). We considered including Women in Physics (WiP) groups as one aspect, but it was recommended that a program with a strong physics club may not have the bandwidth to support a WiP program as well.
- **"Student advising and career mentoring in physics"** recognizes the importance of active advising, which includes giving consistent information and advice, doing regular checks on whether students are enrolled in the proper courses, and offering career mentoring (Hilborn, Krane, and Howes, 2003; Heron and McNeil, 2016; Czujko, Redmond, Sauncy, and Olsen, 2014). Such advising and mentoring can support explicit career tracks (such as teaching tracks) in the physics department (Hilborn, Krane, and Howes, 2003). Advising and mentoring do not necessarily covary: Advising could be strong while career mentoring is absent (e.g.,

learning about students' career aspirations, offering a roadmap of courses, and offering informal mentoring; Hilborn, Krane, and Howes, 2003; Czujko, Redmond, Sauncy, and Olsen, 2014), as described in our Developing level.

5B: Mentoring and Support Toward Becoming a Physics Teacher

- **"Advising of physics teacher candidates"** by a knowledgeable faculty member who "knows how to work the system" is recommended in Vokos and Hodapp (2015). Because the path through licensure requirements is ever-changing, this go-to person must know how the licensure system works to help students graduate in a reasonable timeframe. This is sometimes, but not always, presented by the same person offering career mentoring (below) and thus is included in a separate item. In some cases, the advisor may be in the physics department; in that case, it's best if they have a close relationship with the school of education (this is captured in item 2C-7, "Collaboration on student advising").
- **"Mentoring of physics teacher candidates by a PTE mentor"** is also recommended in Vokos and Hodapp (2015); such a person should have experience in K–12 environments (our Benchmark level) so they can provide a reality check on what the job will be like, the realities of teaching assignments, and common classroom challenges. Our Exemplary level reflects the best-case scenario, where this person has consistent contact with teacher candidates and offers deep personalized mentoring; this was observed within the best programs and was usually provided by the PTE program leader or full-time TIR or, in some cases, cooperating teachers for field experiences or student teaching. While we try to use unidimensional items, both "frequency" and "quality" are included throughout the levels of this item to avoid having two items.

5C: In-service Mentoring and Professional Community

While the PTEPA Rubric focuses on elements that will recruit and prepare future teachers, support of in-service teachers is important for teacher retention, reducing the need to replace teachers who leave the profession (Marder, Brown, and Plisch, 2017; Meltzer, Plisch, and Vokos, 2012) and providing a valuable pool of local teachers to use as cooperating teachers. Continued mentoring of in-service teachers is associated with increased retention in the profession (Gray and Taie, 2015), increasing the retention rate from 71% (for those without a mentor) to 85% (for those with a mentor) across all disciplines. Such ongoing mentoring is also recommended within the T-TEP policy statement.[4]

- **"PTE mentor for beginning teachers"** was revised over time to reflect the *quality* of this mentoring (as opposed to the frequency), as that is what is indicated specifically in the T-TEP report (Meltzer, Plisch, and Vokos, 2012), and we did not want to set a bar for mentoring frequency that was too high to be realistic for early-career teachers.
- **"Professional development for in-service teachers"** reflects that such professional development both contributes to the knowledge and community of in-service teachers and provides a connection between in-service teachers, program leaders, and pre-service teachers. The number of hours was chosen to match the number of hours often required or recommended for in-service teacher professional development (Desimone, 2011).

Items Removed

- **"Monitoring for student success"** was an item originally in the TEPA instrument measuring whether the program monitored student progress. This item was removed as the school of education typically includes systems for tracking student progress toward requirements, and so it was determined to be less germane to the PTEPA Rubric. We did, however, maintain elements that are about PTE-specific mentoring.
- **"Mentoring during student teaching"** was originally included as a specific element of mentorship. We decided to remove it because the specific mentoring structure (such as the number of observations or feedback given) was an aspect under the school of education's authority, and the expertise of the university supervisor (included in Standard 4) was the most critical element for our instrument.

STANDARD 6: PROGRAM ASSESSMENT

This standard corresponds to a similar standard in the TEPA ("Assessment"), but we renamed it "Program Assessment" to indicate that this is specifically about program-level (rather than course-level) assessment.

6A: Program Outcomes

This component actually measures the key *output* variables that the PTEPA Rubric aims to help programs improve: recruitment, graduation, and persistence. We felt it was important to track these outcomes and thus included them as a component in this standard even though they reflect the outcomes that are assumed to be affected by strength elsewhere in the PTEPA Rubric.

- **“Annual graduation from PTE program”** was chosen to reflect meaningful improvement over the national average; PhysTEC 5+ Award winners would be rated above the Exemplary level.
- **“Annual recruitment in PTE program”** was chosen such that a program at the Benchmark level would meet the Benchmark level of annual graduation rates, assuming some attrition.
- **“Diversity of physics teacher candidates”** is the only place where diversity explicitly appears within the instrument (we originally included diversity of the physics major population but felt this was too tangential to the focus of the instrument). We chose to focus on ethnic/racial diversity as this is a more problematic issue among teacher candidates than gender. This item originally required the PTE candidate diversity to exceed the levels of diversity at the institution (rather than to exceed the national levels), but that was found to be unrealistic at institutions with particularly diverse populations.
- **“Career persistence.”** For this item, levels were difficult to determine, as national statistics for STEM disciplines are not known to be available. Data from Texas (UTeach, 2016; M. Marder, personal communication) showed that 70–80% of Texas STEM teachers remained in the profession by the end of year five, depending on the type of licensure program. The Department of Education reports that 80% remain in the profession after five years across all teaching areas (Gray and Taie, 2015). Between these reports, we decided that 75% would be a reasonable Benchmark level.

6B: Program Evaluation and Improvement

- **“Tracking program metrics”** is included as the basic level of program evaluation and our best version of the “Monitoring for student success” item, which was originally in the TEPA. Such tracking is also recommended by the Council for the Accreditation of Educator Preparation (2016).
- **“Feedback from stakeholders”** merges two originally separate items—“Student feedback” and “Alumni feedback”—for the sake of brevity.
- **“Assessing learning outcomes”** is included due to the American Psychological Association’s recommended best practices of assessment of teacher preparation programs (Worrell et al., 2014). This was included in the PTEPA Rubric due to the fact that such assessments would be administered by the university supervisor, who would be hard-pressed to do so if they were not a physics education specialist. For brevity and clarity, this item condenses information from what were originally two separate items: “Measuring teacher candidate learning outcomes” and “Measuring K–12 student learning outcomes.” We found that these items were overly complicated (e.g., one referred to standardized observation forms and tried to differentiate between student learning during student teaching and students of program graduates) and overly ambitious, despite matching the APA recommendations.
- **“Program improvement from feedback and program data”** reflects the importance of continuous improvement in bettering any program, such as physics programs (Heron and McNeil, 2016), teacher education programs (Coble, 2012; Council for the Accreditation of Educator Preparation, 2016), or any initiative in higher education (Kezar, 2014).

6C: Communication to Stakeholders

- **“Communication within the university”** and **“Communication with university administrators.”** To garner the support of stakeholders, program outcomes and successes should be communicated broadly (Kezar, 2014). Such communication helps those in power to see the importance of initiatives and gives opportunities for university stakeholders to have input (ibid.). Vokos and Hodapp (2015) indicate that such communication should include periodic updates to chairs, deans, and provosts.
- **“Publicity and advocacy”** includes information from an earlier item measuring advocacy, originally included in **Standard 1: Institutional Commitment** and then later in **Standard 2: Leadership and Collaboration**. Since local and national advocacy is important in sustaining physics teacher education programs (Scherr, Plisch, and Goertzen, 2017), we determined that the item could meaningfully be included as an element of stakeholder communication. We also included elements of publicity, such as newspapers, as broad information-sharing can garner additional support (Kezar, 2014). Because schools of education regularly engage in state-level advocacy for teacher education broadly (which may or may not bring attention to or support the PTE program), the item was modified to focus on publicity for the program and state-level advocacy on the part of program leaders. The ultimate goal of such advocacy would be to bring funding to the program and/or reduce time to licensure. National advocacy, while a marker of a leader’s commitment, would not typically affect either of those outcomes.

Items Removed

- **“Placement of teacher candidates.”** This was originally included as an item in *Component 6A: Program Outcomes,* but we suspected that it would not critically differentiate between programs due to the high demand for physics teachers; about 90% of PhysTEC graduates are placed within one year.

ENDNOTES

1 Cited as controversial within "Knowledge Base Supporting the 2012 Standards for Science Teacher Preparation" (National Science Teacher Association), retrieved from http://www.nsta.org/preservice/docs/KnowledgeBaseSupporting2012Standards.pdf.

2 See "Understanding Our Secondary Content in the Sciences Standard" from NCTQ at https://www.nctq.org/review/standards#.

3 See PhysTEC Definitions at https://www.phystec.org/webdocs/Definitions.cfm?.

4 See the T-TEP policy statement at https://www.phystec.org/webdocs/TaskForce.cfm.

5 Note however that NCTQ indicates different credit-hour requirements in states with general science certification (rather than single-subject certification); these requirements include coursework with two minors or at least 50 semester credit hours across the sciences.

6 See the NCTQ's "Teacher Prep Review Standards and Indicators" at https://www.nctq.org/review/standards#; particularly https://www.nctq.org/dmsView/NCTQ_-_Standards_and_Indicators_-_Traditional_Programs.

7 See "Understanding Our Student Teaching Standard" at https://www.nctq.org/review/standards#standard6.

APPENDIX 7

Item Strength and Prevalence Chart

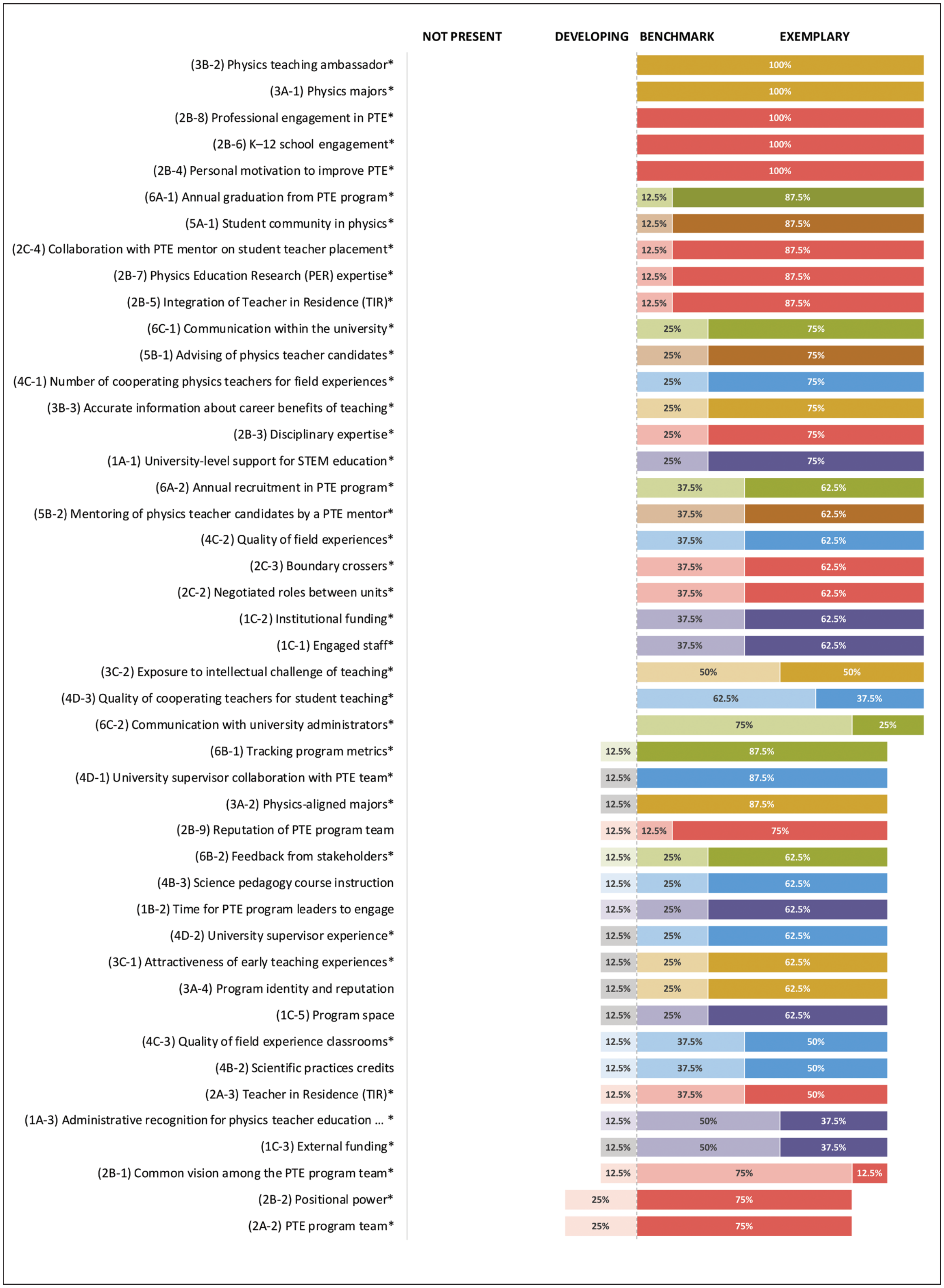
This section shows all PTEPA Rubric items sorted by strength of ratings at thriving programs.

As discussed in Chapter 2, many items on the PTEPA Rubric were identified as Prevalent, indicating that many thriving programs were strong in the item. Prevalent items are those for which (1) at least six of the eight studied programs were rated at least at Benchmark level and (2) those six programs met at least one of our confidence measures (see Chapter 2).

Figure 18 shows every PTEPA Rubric item according to the percentage of items rated at least Benchmark level,[1] with Prevalent items marked with an asterisk (*). Some items are not Prevalent even though a greater number of institutions were rated at least Benchmark on that item compared to neighboring Prevalent items; this reflects the influence of the confidence measures.

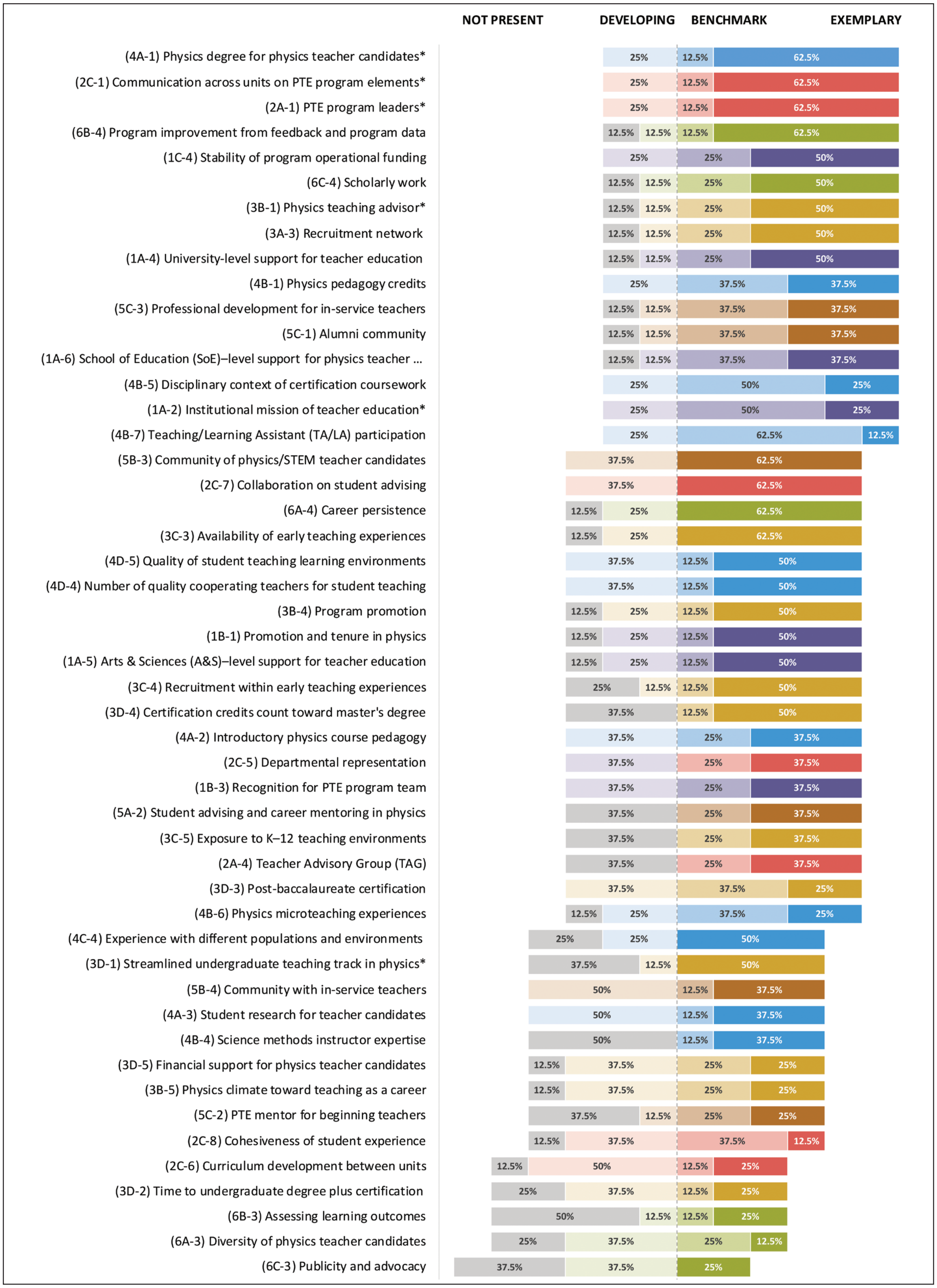
A few items are also only relevant to programs with an undergraduate certification option, which two of the studied programs do not have. For those items, we required five out of the six programs with undergraduate certification options to meet at least the Benchmark level. Those items are all the items within components 3C, 4C, and 4D, plus 3D1 and 3D2.

Figure 18: Complete chart of item strength and prevalence.



Percentage of PTEPA Rubric items that were rated Not Present, Developing, Benchmark, and Exemplary at the studied programs. Prevalent items are indicated with an asterisk (*).

Figure 18 continued: Complete chart of item strength and prevalence.



ENDNOTES

1 In cases where this sorting rated two items as equal, the one with the greatest proportion of items rated at least Developing is listed first.

APPENDIX 8

PhysTEC Theory of Change

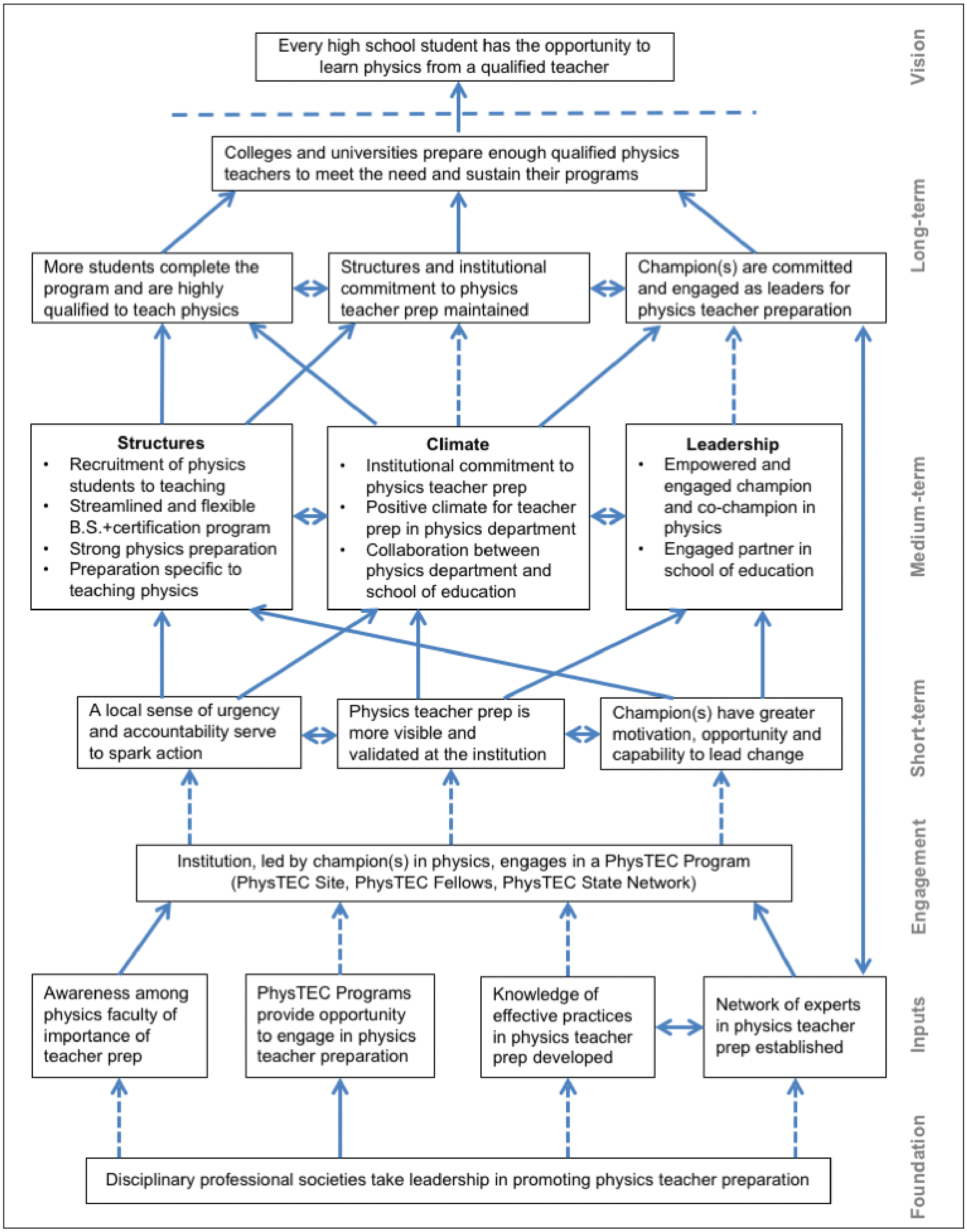
The PhysTEC Theory of Change shows how physics teacher education programs are hypothesized to move toward higher rates of teacher production.

A Theory of Change is a diagram that explicitly lays out the processes that are assumed to lead to the desired change. A Theory of Change is not a generalized theory; it is rather a project-specific diagram of the flow by which the project outcomes are achieved. A Theory of Change can be useful in surfacing the assumptions and expectations of a project and identifying the assessment activities and measures that will be most appropriate for measuring achievement of the desired outcomes. More information about making your own Theory of Change can be found at www.theoryofchange.org.

Below is shown the Theory of Change that was developed to guide the PhysTEC project activities and assessments. While this Theory of Change is specific to the PhysTEC project, a physics teacher education (PTE) program could also follow such a trajectory and achieve these outcomes in other ways.

The PTEPA Rubric is aimed primarily at assessing the medium-term outcomes along this Theory of Change to determine to what degree a program achieves the activities and structures that are likely to lead to long-term, sustainable change. The PTEPA Rubric has evolved since the development of the Theory of Change to include additional elements (such as assessment, student teaching, mentoring, and community), and so there is only partial overlap between the rubric and these medium-term outcomes.

Figure 19: The PhysTEC Theory of Change.



Items in boxes represent outcomes, and arrows indicate which outcomes are dependent on others. Dashed arrows indicate where specific interventions (such as financial awards, recognition, professional development, or publishing tools and resources) are planned by the project to achieve those outcomes. Each outcome is associated with relevant assessments.

A Study of Thriving Physics Teacher Education Programs: Development of the Physics Teacher Education Program Analysis (PTEPA) Rubric

This report presents the results of a study of eight diverse thriving physics teacher education programs, defined as programs at large universities that typically graduate five or more physics teachers in a year. To support other institutions in emulating these successful programs, the study identified common characteristics of such model programs. These characteristics are embodied in a new tool, the Physics Teacher Education Program Analysis (PTEPA) Rubric. The rubric enables characterization of physics teacher education programs and is intended to provide programs with feedback, to guide programs in self-reflection toward improvement, and to provide a means to characterize program growth. This report documents the validation, use, and interpretation of the PTEPA Rubric. Further information about the PTEPA Rubric can be found at http://phystec.org/thriving.

This report was supported in part by the National Science Foundation under grant numbers PHY-0808790 and PHY-1707990 and the APS 21st Century Campaign.