Seeking Consensus on the Essential Attributes of Quality Science and Mathematics Teacher Preparation Programs

Jennifer B. Presley and Charles R. Coble
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Executive Summary

In 2008, A•P•L•U launched its Science and Mathematics Teacher Imperative (SMTI), the goal of which is to increase the quantity and quality of secondary science and mathematics teachers. To achieve the SMTI goal, campus leaders needed guidance on what actions to take. Finding no comprehensive source to describe effective practices or high-quality programs – ones that produce competent novice teachers – SMTI Co-Director, Charles Coble, undertook development of the Analytic Framework (Coble, 2012a), a catalogue of effective strategies along a continuum from recruitment to preparation to induction support for novice teachers. But as the Analytic Framework grew in complexity, senior leaders from A•P•L•U member institutions began to ask, “What are the most critical components or indicators of quality programs?” They wanted to identify the most important levers to push to promote program improvement and quality on their campuses and beyond. We recognized that this question was important not only to A•P•L•U’s constituency, but to a wider audience with interest in examining the quality of teacher preparation programs.

In order to address this challenge, the authors embarked upon a different path than the usual reviews of research and reports. We recruited 32 national teacher-preparation experts, practicing teachers, and policy leaders for individual telephone interviews and 45 representatives of six disciplinary and professional societies for group interviews.

Respondents were asked to describe their vision of the key characteristics of an ideal science and mathematics teacher preparation program, and questions about their view of the status of program evaluation, and research evidence for program and teacher quality. Our analysis of the response data identified clear consensus conclusions from these people who are deeply engaged in and knowledgeable about secondary science and mathematics teacher preparation. We defined consensus as near, but not necessarily complete, unanimity. The results were compiled into four thematic briefs that are detailed in full in the report, and are highlighted below. Interviewees and focus-group representatives were invited to Boulder, Colorado, for an intensive one-and-a-half day colloquium to engage in a deeper discussion going beyond the original protocol questions into questions of implementation.

FOUR THEMES EMERGING FROM THE INTERVIEWS AND FOCUS GROUPS

Theme #1: Entry and Exit Requirements

Consensus Statement: It matters a great deal who is selected into and who exits from teacher preparation programs, but quality control of who enters and who exits programs is not done well across the country.
The right conditions and incentives are not in place to recruit consistently strong teacher candidates to prepare for careers in science or mathematics teaching.

We want candidates who are academically accomplished, passionate about teaching young people, and persistent in achieving their goals.

Recruitment needs to be much more deliberate, rigorous, and selective for the knowledge, skills, and dispositions associated with good teaching in mathematics and science.

There should be rigorous standards and performance assessments for all candidates seeking teacher licensure in science and mathematics.

**Theme #2: Clinical Preparation**

**Consensus Statement:** Learning to teach should primarily be a clinical practice thoroughly grounded in the realities of schools and classrooms.

- Well-sequenced and well-supervised clinical experiences should provide teacher candidates with realistic experiences upon which to base their decisions to pursue teaching and, for those that do, to prepare them well for the realities and the possibilities of teaching.
- Teacher candidates should be engaged in and experience the art and craft of teaching early and often.
- Recognized master teachers and teachers-in-residence should play a key role in the clinical preparation of teachers.
- Clinical experiences should be in a range of grades in schools that closely mirror where teacher candidates’ ultimate placements will likely be.
- There should be strong support for program completers through their critical induction period into teaching.

**Theme #3: Knowing and Teaching Disciplinary Content**

**Consensus Statement:** Teachers need to both know the discipline they are teaching and have the pedagogical skills to teach it, requiring deep collaboration between education and disciplinary departments.

- There is no one best program design. But all programs must be rigorous and accommodate students at different points in their education, their lives, and their financial circumstances.
- Pedagogical content knowledge needs a more prominent place in program design and should be blended into the instruction of content courses.
Out-of-classroom experiences help teacher candidates gain an understanding of the nature of the discipline beyond what they can acquire in classes.

Education and disciplinary faculty, along with master teachers and teachers-in-residence, need to create strong partnerships.

No matter the discipline of training, teachers need to be able to make cross-disciplinary connections in their teaching.

**Theme #4: Evaluation and Research to Improve Teacher Preparation**

**Consensus Statement: There is a need for ongoing evaluation within programs, and better research to inform the design and development of teacher preparation programs.**

- Continuous evaluation of every phase of teacher preparation programs, including strength of school partnerships, is essential for their ongoing improvement.
- We need to know much more about what constitutes effective practices both in teacher preparation and in the K-12 classroom, and how to measure them.
- Too few education researchers undertake research that will produce results that are directly applicable to teachers and classrooms, and there are too few doctoral programs that produce the kinds of researchers needed to conduct such research.
- While there is no one best structure for science and mathematics teacher preparation, what is known about attributes of successful program components needs to be communicated faster and more clearly.

These consensus statements demonstrate that there is considerable agreement among a broad spectrum of experts across the nation with regard to what it takes to prepare high-quality teachers. There is a strong foundation of agreement upon which strategies for action can build. But what was quite different from the current search for post-preparation evidence of teacher quality was a call for continuous quality improvement processes that examine every step along the pipeline of teacher preparation. Evaluation in this context is conceptualized as an ongoing formative process that each and every program should be practicing on a continuous basis. Teacher preparation programs most certainly must be held accountable for the performance of their newly certified teachers, perhaps through a nationally applied approach such as edTPA (AACTE, 2012). But in a continuous improvement model, this is not an after-the-fact judgment of quality, but instead a point along the teacher preparation pathway from recruitment through preparation and into practice.
TEN KEY QUESTIONS UNIVERSITY LEADERS SHOULD ASK

We began this project intent on identifying key attributes of quality teacher preparation programs. In addition to our confirmation of the strong foundation of agreement for action, and the importance of continuous formative evaluation, we were able to draw upon all of the data gathered from interviews, focus groups, and the Boulder Colloquium to craft a list of ten key questions that can guide college and university leaders, and others wanting to gain insight into the quality of teacher preparation programs under their purview. It is the authors’ hope that institutional leaders and others responsible for ensuring that preparation programs produce competent novice teachers will use these questions to guide their quest for quality in their teacher preparation programs. In a companion paper (Coble, 2012b) these ten questions have been mapped to the Goals, Objectives, and Strategies of the Analytic Framework. This provides some practical guidance for implementing or improving these program practices.

1. How do you as a leader convey a clear and strong message for the value of quality teacher preparation at your institution? What evidence can you present to affirm your commitment?

2. Does the selection process into teacher preparation programs attract candidates with demonstrated academic success and evidence that they have the skills and dispositions that will likely lead to their becoming good teachers? What data are available to support the response?

3. Are there exit standards beyond minimum state requirements that ensure that the teacher education programs produce competent novice teachers? What, specifically, are the higher exit standards if they exist?

4. Do teacher preparation programs have a culture of evidence and accountability, one that tracks and assesses the progress of teacher candidates from entry to completion and as novice teachers and uses those data to make appropriate interventions and program changes as warranted? Is a comprehensive assessment plan in place, are data being collected and is there evidence that the data are being used to counsel students and improve the program?

5. Is teacher preparation clinically based, all the way from early classroom exposure, to more extensive, but still well supervised student teaching? Is there a documented sequence of clinical development and evidence of effective monitoring and mentoring by skilled professionals?

6. Do teacher preparation programs blend courses in disciplinary content and pedagogical content knowledge so that students acquire deep content knowledge and the ability to transmit core disciplinary concepts in an age-appropriate way? Is there evidence of such content-pedagogical integration and agreement on its effectiveness by disciplinary and pedagogical faculty?
7. Do programs have vigorous university-school partnerships that demonstrate a shared responsibility for teacher preparation and development with the public schools in which most teacher candidates are placed for clinical experiences and student teaching? Is there evidence that the partnerships are recognized formally and show evidence of sustainability?

8. Are master teachers and teachers-in-residence, those with strong disciplinary backgrounds and evidence of exemplary understanding of teaching, engaged as essential colleagues in teacher preparation? What is the evidence of teacher engagement and the impact of the engagement?

9. Do the teacher education programs ensure that co-operating classroom teachers assigned to student teachers are master teachers or are teachers under the supervision of a master teacher in the school or district? What is the evidence that selection, preparation, and compensation of cooperating teachers assure effective development of teacher candidates?

10. Do the teacher education programs include support to their novice teachers through an induction period as a part of their formal programs? What specific programs of induction support are in place and what evidence of impact is available?

What remains to be done is to build criteria and metrics for assessing the degree to which these strategies are successfully being implemented within programs. This would help programs as they undertake their individual, ongoing assessment for continuous improvement, but might also lead to the development of a national competition to recognize exemplary teacher preparation programs.

**CONCLUDING COMMENTS**

The lack of empirical evidence has not impaired decision-making and program development in teacher preparation. The models and portals of entry into science and mathematics teacher preparation programs continue to proliferate across the United States. And while the authors fully support innovative program design, we also support an adherence to attributes of quality. Research drawn from the collective wisdom and judgments of quality by experts with a variety of perspectives on teacher preparation can add to the knowledge base, as we have attempted to do with rigor in this project. In that way, we trust this work will be useful to a wide audience.
Introduction

In 2008, A•P•L•U launched its Science and Mathematics Teacher Imperative (SMTI), the goal of which is to increase the quantity and quality of secondary science and mathematics teachers (A•P•L•U, 2012). To achieve the SMTI goal, campus leaders needed guidance on what actions to take. Finding no comprehensive source that described effective practices or high-quality programs – ones that produce competent novice teachers – SMTI Co-Director, Charles Coble, with colleagues, undertook the development of a common framing tool called the Analytic Framework (Coble, 2012a). It is a catalog of effective strategies along a continuum of teacher development that embraces four components of teacher development: recruitment, preparation, induction, and development, plus the important, but often unrecognized fifth component of leadership, policy and infrastructure (Coble et al., 2012). The content of the Analytic Framework has been designed as a comprehensive self-assessment tool that enables teacher educators, content specialists, campus leaders, and school partners to carefully examine their programs and use the resulting information to improve their science and mathematics teacher preparation programs. It is a useful tool, but as the Analytic Framework grew in complexity (5 goals, 13 objectives, and 56 strategies), senior leaders from the A•P•L•U/SMTI Executive Committee, composed largely of presidents and chancellors of large public universities, began to ask, “What are the most critical components or indicators of quality programs?” They wanted to identify the most important levers to push to promote improvements and quality on their campuses and beyond.

In order to address this challenge, we embarked upon a different path than the standard review of research and reports (for example, Cochran-Smith and Zeichner, 2005; Cochran-Smith et al., 2008; National Research Council, 2010; and Wilson et al., 2001). Instead, 32 national teacher preparation experts, practicing teachers, and thought leaders were recruited for individual telephone interviews, and others were asked to participate in group interviews as representatives from six disciplinary or professional societies. An additional 45 respondents participated in six focus-group sessions with disciplinary society and professional association groups. The full list of participants is provided in Appendix A. Respondents were asked to describe the key characteristics of their vision of an ideal science and mathematics teacher preparation program, and to respond to questions about the status of program evaluation and research evidence for program and teacher quality. While the authors developed a structured set of protocol questions, respondents were given the freedom to be as expansive (or narrow) in their responses as they wished. A full description of the research methodology is provided in Appendix B.
Themes Emerging from the Interviews and Focus Groups

The analysis of the response data identified some clear consensus conclusions across the individual and focus groups participants, all people who are deeply engaged in and knowledgeable about secondary science and mathematics teacher preparation. (For these purposes we defined consensus as near, but not necessarily complete, unanimity.) From the analysis four themes emerged:

1. Entry and Exit Requirements;
2. Clinical Preparation;
3. Knowing and Teaching Disciplinary Content; and
4. Evaluation and Research to Improve Teacher Preparation.

The results were compiled into four thematic briefs, each with subcomponents listed as questions. For each of the questions under each theme, we provided a brief answer that conformed to the consensus opinion of the interviewees and focus groups. The answer to each question was then further explained, and in every case we attempted to be true to the comments gleaned in the interviews and focus groups. Each of the thematic briefs is provided in the next sections.
Theme #1: Entry and Exit Requirements

CONSENSUS STATEMENT FOR THEME #1: It matters a great deal who is selected into and who exits from teacher preparation programs, but quality control of who enters and who exits programs is not done well across the country.

Responses are organized under four major questions:

1. Do we have the right conditions and incentives in place to recruit consistently strong teacher candidates to prepare for careers in science or mathematics teaching?

2. Are we clear about the characteristics and abilities we are looking for in individuals we recruit and select into science and mathematics teacher preparation?

3. Ideally, what processes and procedures should we use to recruit and select accomplished individuals to prepare for teaching science or mathematics?

4. Should there be nationally agreed upon exit standards for certification in science and mathematics teaching?

1. Do we have the right conditions and incentives in place to recruit consistently strong teacher candidates to prepare for careers in science or mathematics teaching?

CONSENSUS STATEMENT 1.1: As a profession and as a nation, absolutely not!

As several respondents mentioned, teachers in most other countries, especially in high-performing nations as measured by performance on international science and mathematics exams, are recruited into prestigious teacher education programs using high standards for entry, and program graduates are held in high regard as professionals. Policies and public attitudes are in place in those countries to attract some of their most capable citizens to prepare for teaching, to become teachers, and to remain in teaching for a career. By contrast, in the United States, while teachers usually are respected in their local communities, neither the teaching profession in general, nor college and university-based teacher education, are held in high regard.

However, respondents identified other significant deterrents to attracting strong candidates to prepare for teaching in American schools. Most notable was the lack of a sense of career advancement in teaching in the United States. As suggested by respondents, this is a powerful disincentive for individuals, especially young people, to choose to prepare for teaching. Teaching as a career seems too ‘flat’ in terms of advancement and new challenges, and the thought of preparing to do the same thing year after year is not attractive to bright, accomplished prospective candidates who have other career options. As one interviewee said:
"I was able to attract really excellent students who really liked kids and where I think we prepared them reasonably well for teaching, but they could not figure out a career path going forward; there was no progression based on their accumulated knowledge and skills learned as a teacher. They were smart and could project out to their mid-career and could see little difference in what they were doing as a beginning teacher and what they would be doing near the end of their career – there was (and is) no systematic progression in teaching."

A significant area of concern noted by respondents relates to the general conditions under which most teaching is practiced, particularly the isolation of teachers in classrooms and the general irony of public school teaching in the United States being largely a private solo act. Attracting and retaining young people, or even career changers, into a profession as isolating as teaching is a huge challenge and a source of continuing discontent and churn in the profession. Unlike other countries, it is rare for U.S. teachers to work with teams of professional colleagues to create lessons, observe each other teaching lessons, assess student outcomes, and cooperate in solving teaching-learning problems. By contrast, what is rare in the United States is common in high-performing nations. As a National Board Certified teacher we interviewed said, "I think we need to stop trying to fix teachers and fix the conditions in which teachers teach! We need to change the work."

As for teacher pay, respondents felt it was a barrier to entry for some who would otherwise consider teaching as a career.

2. **Are we clear about the characteristics and abilities we are looking for in individuals we recruit and select into science and mathematics teacher preparation?**

**CONSENSUS STATEMENT 1.2: We want candidates who are academically accomplished, passionate about teaching young people, and persistent in achieving their goals.**

While the specifics about who should be recruited into science and mathematics teaching were stated differently, the comments can be grouped into four categories. Teacher candidates should: (a) be academically successful and have a keen interest in the discipline(s) they wish to teach; (b) possess aptitude and personality characteristics that enable them to relate well to K-12 students; (c) have a sense of mission and passion for teaching young people; and (d) have a reflective disposition with an inclination to persist in the face of complexity and lack of immediate success.

These four categories do not fully capture the richness of the discussions, since many other specific ideas about recruitment surfaced in the interviews and focus group meetings. For example, some felt that far too much interest was being placed on recruiting the academically
brightest and the best, often conceived to be the top 10% of science and mathematics students. Obviously, the pool of candidates that match that description cannot come close to meeting the very large number of teachers needed to staff the nation’s classrooms. However, there is likely to be a sufficient pool if it is defined as the top two quartiles academically. But respondents were not satisfied with thinking about academic performance as the sole criterion for selection. One interviewee captured the sentiments of others in saying: “I would [also] be looking for candidates who had been involved in such things as coaching, tutoring, church activities, scouting, clubs and the sort, something that showed a clear disposition to want to work with kids.” Another interviewee recommended: “…we should be recruiting candidates who see themselves as change agents and who see themselves as the primary locus of control of their environments.”

Respondents also emphasized the importance of what happens in the preparation program, in addition to the issue of selecting academically capable candidates. They expressed the view that well-designed programs could take accomplished candidates, not just the top performers (which the authors inferred to be those in the top 10% of high school graduates) and prepare them to be excellent beginning teachers. As another interviewee said: “There are not enough people in the top tier of academic achievement to fill the classrooms of America, but if we rethink the profession, there are enough bright and passionate people who would want to prepare for an engaging teaching profession.” Some who were familiar with teacher residency programs felt there was evidence that program effects, particularly the multi-level teams that characterize many residency programs, are powerful enough to override somewhat lower academic selectivity. One interviewee noted, “Selection is powerful, but it is not everything. Programs can compensate for weaker student pool quality.” But it was agreed that prospective teachers need to bring a strong foundation of academic capital to their preparation for teaching. Even strong programs cannot remediate poor academic preparation, and it should not be the mission of preparation programs to accept and train all-comers who express a desire to be a teacher.

An additional point made by respondents relates to the sources of possible candidates. Universities should be providing opportunities for potential candidates to consider teaching as a career, especially those entering college with college-ready skills and interests in science and mathematics but without plans to become teachers. Great teacher candidates may be currently enrolled as majors in academic departments and in nearby community colleges. In addition, they may be in business and industry or even working as non-teaching employees of schools. The design of programs, it was felt, should accommodate potential teacher candidates from a variety of different entry points.
3. Ideally, what processes and procedures should we use to recruit and select accomplished individuals to prepare for teaching science or mathematics?

CONSENSUS STATEMENT 1.3: Recruitment needs to be much more deliberate, rigorous, and selective for the knowledge, skills, and dispositions associated with good teaching in mathematics and science.

The general sense from respondents is that college and universities are seen as focusing almost exclusively on screening and accepting from those who choose to apply for entry into their teacher education programs. In addition, institutions are perceived to be doing a poor job of actively recruiting and selecting applicants for admission into teacher preparation. In part this condition may stem from a lack of core funding to engage in the kind of incentives and recruiting functions that characterize Teach for America, the Woodrow Wilson Teaching Fellowship, Math for America, The New Teacher Project, and other program recruitment strategies. However, UTeach, the Learning Assistants model, and a few other university-based programs have demonstrated that by focusing on recruiting high-performing students majoring in the sciences and mathematics, universities can successfully attract academically capable students with a passion for teaching.

Most felt that one of the persistent problems plaguing many universities in attracting some of the most capable students into teacher preparation lies in the attitudes and actions of disciplinary faculty in the sciences and mathematics that actively discourage their high-achieving students from entering K-12 teaching. Faculty are powerful influencers; disciplinary faculty, at a minimum, should not send discouraging messages to capable students who express an interest in teaching, thus making recruiting such students more successful.

Some respondents with extensive knowledge of recruitment processes in higher-performing nations pointed to far more rigorous, multi-staged recruitment strategies that begin with a paper review with various screens for selection, such as a high GPA average in one’s major subject area, and/or certain scores on national exams such as SAT/ACT. Teacher candidates then prepare essays reviewed against specific criteria and complete screening tools similar to those used by Uncommon Schools or Teach for America to assess evidence of interest, leadership potential, and level of locus-of-control or other attributes commonly associated with effective teaching.

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1 See, for example:
with effective teaching. After this first-level vetting, prospective teacher candidates are interviewed by a school principal and/or a master teacher who looks for personality indicators that determine how a candidate will likely relate to students. Depending on the outcome of the interviews, faculty members conduct additional interviews prior to admission into a preparation program. Additionally, early clinical experiences that allow potential candidates and school-university teams to critique the candidate’s interest and readiness to be accepted into preparation programs are part of the screening process.

An observation made by several interviewees was that the best possible recruitment strategy would be for pedagogical and disciplinary faculty, working closely with K-12 educators in partnership schools, to design and implement a powerfully engaging mission-driven clinically-based teacher preparation program – one that remains connected to its program completers as beginning teachers and extends professional growth opportunities far into their careers. One interviewee stated: “A preparation program with a vision of the long arc of teacher preparation and development, grounded in practice, would develop a reputation for quality and rigor that would virtually assure a near endless supply of accomplished, passionate, and eager teacher candidates.”

4. **Should there be nationally agreed upon exit standards for certification in science and mathematics teaching?**

**CONSENSUS STATEMENT 1.4:** There should be rigorous standards and performance assessments for all candidates seeking teacher licensure in science and mathematics.

Respondents generally felt that while recruitment and selection were important, the larger concern is what teacher candidates should know and be able to do prior to being recommended for licensure by the state. There was general support for developing a set of rigorous standards and performance assessments that must be taken by all candidates seeking teacher licensure in science and mathematics (and other areas as well). The process envisioned would be much like the state assessment consortia that have developed in response to the Common Core State Standards (Common Core State Standards, 2010). The implementation of new standards and performance licensure examinations would be similar to law exams following law school or medical exams that follow medical school preparation. These rigorous examinations are developed by the experts in the profession, distinct from

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2 The term master teacher is currently used in a variety of ways. For some, it represents classroom teachers who best demonstrate the skills needed to teach their subjects. For others, it represents those teachers who are selected to work as faculty of practice within the preparation programs, usually acting as advisors to students as they undertake their pre-clinical practical experiences. In this paper, we use master teacher to connote the currently practicing classroom teacher. For the latter, we use the term teacher-in-residence – someone who may well have been a master practicing teacher.
specific training programs, are recognized by state licensing bodies, and apply to all who aspire to practice law or medicine. The same could be true for those who aspire to be teachers.

The proposed state-led or professional society-led standards-setting process and performance examinations for teacher licensure would alter the current licensing paradigm which does little to reduce the variability in the quality of graduates from teacher preparation programs and which does little to inspire confidence in the quality of teacher preparation. Higher standards and performance examinations would shift the focus from program inputs and what teacher candidates know, to outputs and what teacher candidates are able to do. (We note that edTPA, which has recently been announced by the American Association of Colleges for Teacher Education, has the potential to begin to meet this need (AACTE, 2012).)
Theme # 2: Clinical Preparation

CONSENSUS STATEMENT FOR THEME #2: Learning to teach should primarily be a clinical practice thoroughly grounded in the realities of schools and classrooms.

Responses are organized under five major questions:

1. What are the purposes of clinical preparation?
2. What is the ideal scope and sequence of clinical experiences?
3. Who should supervise teacher candidates through clinical experiences?
4. Where should clinical experiences occur?
5. What are the universities’ responsibilities for the success of beginning teachers?

1. What are the purposes of clinical preparation?

CONSENSUS STATEMENT 2.1: Well-sequenced and well-supervised clinical experiences should provide teacher candidates with realistic experiences upon which to base their decisions to pursue teaching and, for those that do, to prepare them well for the realities and the possibilities of teaching.

Respondents articulated a common purpose for early clinical experiences: They can and should provide teacher candidates with realistic experiences upon which to base their decisions about whether or not to pursue teaching. Similarly, they can provide information to faculty and cooperating teachers about the readiness of candidates to teach their subject.

Respondents felt that carefully designed clinical experiences, combined with follow-up discussions, can help teacher candidates create a stronger sense of their commitment to become science or mathematics teachers and help them clarify a vision for effective teaching in their discipline. Through their engagement with accomplished teachers, teacher candidates can also begin to envision how they can advance and grow in a teaching career. Clinical experiences should help build the motivation and capacity of teacher candidates to engage with other teachers in solving problems. They should begin to feel a sense of success as teachers as they improve their abilities to address the different levels of student knowledge and interest in the content, and in learning. As one interviewee summarized: “Clinical experiences should help candidates build a clear idea and conviction about the real purpose of teaching and develop the ability to convince students (and sometimes their parents) that it is possible to attain these purposes.”
Clinical experiences generally tend to reinforce the dominant and isolating stand-alone model for teaching as the only model for teaching. Through engagement with partner schools and teacher preparation programs, master teachers and other cooperating teachers could be supported to engage in more collaborative teaching models that include how to mentor teacher candidates. A redesigned teaching model might be similar to studio practice where teachers involved in clinical programs function as a supportive community of practitioners learning together how to improve their work and have a positive impact on students. Thus, another purpose of clinical experiences could be to introduce a newer, more team-oriented, and collaborative model for teaching.

2. What is the ideal scope and sequence of clinical experiences?

CONSENSUS STATEMENT 2.2: Teacher candidates should be engaged in and experience the art and craft of teaching early and often.

Respondents felt that traditional university-based teacher preparation programs front-loaded theory, as is evidenced by required courses in the history and philosophy of education taught by education faculty as foundations for learning to teach in K-12 schools. While the content of these courses was not seen as unimportant, respondents presented these as less central to the more immediate concerns of teacher candidates. They stressed the importance of teacher candidates having clinical experiences early in their training program so they can understand the context of schools and communities, and thus are closer to the work teachers do. Preparation programs ought to focus more directly on helping teacher candidates become skillful at managing issues that relate to the work of teachers.

There was agreement that clinical experiences should be front-loaded for teacher candidates and should extend and deepen in intensity over time. Each clinical experience should have a specific purpose, with each successive experience contributing to building a scaffold of knowledge. As such, a program’s clinical experiences should be developmental, providing teacher candidates with opportunities to demonstrate growth in teaching through cycles of well-supervised practice, reflective analysis, and feedback over an extended period of time in school settings. Teacher candidates should also have clinical experiences in a progression of grades, irrespective of which level they ultimately intend to teach, as it is important for teacher candidates to see how students’ learning progresses with age. As one interviewee concluded: “Clinical experiences should help teacher candidates build a clear and specific picture of how students learn individually and in school settings – and that they can learn.”

While there was general agreement that clinical experiences needed to come early for teacher candidates, respondents cautioned against early experiences that are full immersion,
believing that learning to teach on the job in real time may not create the best teachers. The action is too fast, the experience is too narrow, the support is much too thin, and there is no time for reflection.

Respondents felt that prospective teachers must be grounded in the realities (and possibilities) of schools. Such structured exposure over a period of time through a teacher preparation program will help candidates not only develop and refine teaching skills, but evoke increasingly sophisticated questions from them about teaching and learning, supported by their engagement with K-12 teachers and university faculty with regard to their questions and observations. Teacher candidates need to see clearly what good teaching in their discipline looks like and formulate answers to these types of questions: What are teachers doing when students seem motivated, on-task, and learning? How do different teachers create engaged learning environments? What are students doing? What kinds of questions are students likely to ask and how do teachers respond to and foster them?

3. Who should supervise teacher candidates through clinical experiences?

**CONSENSUS STATEMENT 2.3:** Recognized master teachers and teachers-in-residence should play a key role in the clinical preparation of teachers.

Those interviewed believed that the current placement of teacher candidates in schools for field and clinical experiences is haphazard. Too little attention is placed on whom and what teacher candidates are observing. Moreover, too little attention is given to preparing classroom teachers to mentor and coach student teachers. The placement of teacher candidates needs to be with teachers and in environments that reflect the best models of teaching in their subject. To the extent possible co-operating teachers should be recognized master teachers who possess advanced knowledge, skill and wisdom to transmit best practices in teaching and learning to the next generation of teachers. In addition, teachers-in-residence, those who could be characterized as expert artisans of teaching and who are integral members of the program faculty, must become much more central to the preparation of new teachers and be seen and acknowledged by the university as essential team members in teacher education.

There is no rule that prohibits multiple teacher candidates from being assigned to one master teacher or a master teacher supervising the student teaching experience of candidates placed with other teachers in their school or district. Teachers-in-residence should also mentor teacher candidates throughout their field and clinical experiences. A leader of a major national program stated: “Content knowledge needs to be linked to how students learn, and master teachers [and teachers-in-residence] know how to do this. They are key in setting up a successful program.” However, there must first be a mechanism to identify, develop,
and support master teachers and teachers–in-residence to play these critical roles as part of a coherent teacher preparation program. As a prominent policy leader noted: “In the U.S., we don't even have a [uniform] way to classify master teachers. Filling this void must be an important part of the process of changing teacher preparation - to identify and deploy master teachers [and teachers-in-residence] as a crucial part of the process of preparing teachers.”

Respondents acknowledged a limited supply of teachers who formally or informally can be called master teachers, and the number of teacher candidates is likely to exceed that limited supply. However, it was suggested that master teachers could have cohorts of teacher candidates observing, planning, and delivering lessons and giving feedback to each other in cycles of practice and reflection. A cohort model would not only serve teacher candidates better by learning under the tutelage of a great teacher, it would serve the professional needs of the master teacher as well. University recognition and engagement of the special talents of master teachers would help break the pattern of teacher isolation and simultaneously model a rewarding career path for teacher candidates where they can maintain their status as classroom teachers. Extensive development and collaborative use of master teachers is common in some of the highest-performing nations in the world – and yet is uncommon in the United States (Stewart, 2012).

4. Where should clinical experiences occur?

CONSSENSUS STATEMENT 2.4: Clinical experiences should be in a range of grades in schools that closely mirror where teacher candidates' ultimate placements will likely be.

Respondents felt that the general model of clinical experiences for science and mathematics teacher preparation is too general and not sufficiently responsive to the needs of many districts that are genuinely attempting to improve the achievement of the growing number of poor and low-performing students. They explained that currently, the primary criteria for clinical placements in schools are geographical proximity to the university or “back home” for the convenience of the student teacher. While this practice is understandable, it is insufficient. The relationships between most universities and districts are more transactional than reflective of genuine partnerships where both parties have a stake in the long-term preparation of teachers who can work effectively to improve student success in these schools, not just schools in general.

Some of the nation’s largest urban school districts have created district-run teacher residency models to address their need for more and better-prepared science and mathematics teachers. Teacher residency programs focus on selecting and preparing candidates to teach the district’s curriculum successfully to poor and historically underachieving students. If
urban-serving universities want to continue playing (or regain) a stronger role in teacher preparation, they must make a long-term commitment to helping improve student success in schools serving poor and historically low-achieving children. Teacher candidates need clinical field experiences linked to successful master teachers in both improving schools, and in high-performing schools. Universities can be essential partners in creating and supporting those successful schools and teachers.

Respondents considered clinical placements just in classrooms and with grade levels associated with the expected area of teacher certification to be too limited. Teacher candidates should observe classes across age and grade levels to get a sense of what comes before and after in the curriculum. To better understand the context of the communities in which the schools exist, teacher candidates would benefit from “rounds” in local after-school programs, Boys and Girls Clubs, and other community-based programs for youth.

Finally, some respondents felt that teacher preparation programs may be under-appreciating and therefore under-utilizing alternatives to clinical experiences in actual schools as the only way to learn about and practice teaching. Teacher candidates can learn from videos, simulations, or avatars as supplements to on-site clinical experiences. These uses of technology have the obvious advantage of allowing the action to be slowed down, analyzed, and repeated as many times as necessary. One prominent interviewee went so far as to say: “Student teaching is a scam; junk student teaching. Replace it with a thoughtful inquiry into teaching using videos and simulations. These students would slowly make their way into teaching using simulations with a different task about teaching to do every day while being well supervised. Then build on this with more intensive work with students.”

5. What are the universities’ responsibilities for the success of beginning teachers?

CONSENSUS STATEMENT 2.5: There should be strong support for program completers through their critical induction period into teaching.

Respondents recognized that like all other beginning professionals, novice teachers are not expert. To become expert they need nurturing and support in their beginning years of teaching. The teacher preparation programs where they initially developed their skills and where trusting relationships were built should be a part of that support structure for novice teachers. Historically, support for beginning teachers has not been part of the university’s mission and there is no sustained funding model to provide support to beginning teachers. However, given the increased focus on accountability and what we know about the needs of beginning teachers, more universities must find ways to make this happen. While some programs may conceptualize and deliver support directly (and only) to their program
completers, others embed their support for beginning teachers within the context of specific schools, so that their graduates and other novice teachers are supported to transition into a community of practice that extends and supports their continuing development. One leader in mathematics education commented that teaching has become a lonely profession and recommended: “Universities could provide a lot of support, such as visits to classrooms, creating networks to exchange information, and linking math professors with teacher education graduates and to master teachers.”
Theme #3: Knowing and Teaching Disciplinary Content

CONSENSUS STATEMENT FOR THEME #3: Teachers need to both know the discipline they are teaching and have the pedagogical skills to teach it, requiring deep collaboration between education and disciplinary departments.

There also was broad agreement that disciplinary faculty who are teaching introductory courses (at a minimum) must reform their own approaches to teaching so that college students experience exemplary teaching. And, there must be a goal to teach all students for success, not to weed them out. During the chemistry focus group, the idea emerged for ACS to initiate a certification program for high-quality university chemistry teaching that is rooted in an understanding of scientific teaching. One focus group participant suggested, “You could ask how many ACS-certified college instructors are part of the training program, versus Nobel laureates.”

There was general agreement that teaching mathematics and science are different enough to warrant some differences in preparation. All agreed that the general components of any teacher preparation program, including mathematics and science, are the same, and must include well-designed field experiences and highly skilled master teachers. But respondents noted that disciplinary content differs significantly and thus teaching strategies must be different. Many noted that the same pedagogical courses will not work for both science and mathematics, since content ought not be separated from strategies to teach it and thus are simultaneous learning events.

We address what emerged as five components of the ideal relationship between the acquisition of disciplinary content and pedagogical content knowledge (PCK). They are presented here as the following questions:

1. Is there an ideal structure of a mathematics or science teacher preparation program?
2. How is pedagogical content knowledge best delivered?
3. How important are out-of-classroom experiences for teacher candidates?
4. How can connections across education and disciplinary departments be strengthened?
5. How do programs address state and district demand for broad-field science certification versus more in-depth single disciplinary science certification?
1. Is there an ideal structure of a mathematics or science teacher preparation program?

CONSENSUS STATEMENT 3.1: There is no one best program design. But all programs must be rigorous, and accommodate students at different points in their education, their lives, and their financial circumstances.

In response to this question, preferences varied. Some respondents preferred a five-year program for teacher preparation, beginning with a major in the discipline followed by a year of learning to teach. Others preferred an undergraduate program, although there were different views of what that should be, e.g., a separate program to prepare teachers in the college of education, an education path within the disciplinary major, or a minor in education. Views seemed to depend on respondents’ own experiences and programs. Most agreed that general pedagogy courses were of limited usefulness to science and mathematics teacher candidates.

Respondents spoke about the general education component of the curriculum, with agreement that less attention needs to be given to topics such as the professional role of teachers and perspectives on the profession. They felt that these are not the most pressing issues in preparing teachers, and while it is important for teachers to understand the context of teaching, that learning needs to be more closely related to the work teachers do as teachers. On the other hand, one practicing teacher commented that she wished she had had a course on education policy, so that she could understand current issues of assessment, performance, and funding, all of which directly related to her most pressing issues regarding her work.

All respondents agreed that it was important to have rigorous programs that could accommodate students at different points in their education, their lives, and their financial circumstances. Furthermore, all agreed that it is essential for teacher candidates to receive a thorough exposure to the discipline in order to acquire an understanding of disciplinary content and the ways of thinking that undergird the discipline. Respondents talked about a “connection to the discipline” and ways of thinking about the discipline that are quite different even within the sciences. As one focus-group participant added: “They don’t have a unified big picture of the discipline. Math teachers see math as a layer cake of topics and science teachers see science as a Chinese menu to pick and choose from. Therefore, those who are teaching don’t understand science or math.”

A mathematician asserted that science disciplines provide more solid grounding in ways of thinking about the discipline than does mathematics, although sometimes to the detriment
of providing opportunities for understanding science content in order to be able to teach it. Another respondent commented that with the general public’s direct access to science knowledge now, science teachers should shift their focus from covering content to helping children think scientifically. This respondent continued by saying, “Teaching and learning can be elevated to ‘applications of knowledge’.”

2. How is pedagogical content knowledge best delivered?

**CONSENSUS STATEMENT 3.2:** Pedagogical content knowledge needs a more prominent place in program design, and should be blended into the instruction of content courses.

Many respondents commented on common problems that pervade both science and mathematics, and probably other areas of teaching, too. For example, university-level coursework is usually only partly responsive to the academic training pre-teachers need in the major, and their courses are not aligned with the knowledge that is needed to teach high school curricula. A chemistry focus group member asserted that the current separation of chemistry content and pedagogy courses was an artifact due to the lack of expertise in chemistry education research.

There was strong support for the argument that mathematics methods courses are very different from science methods courses because of differences in the ways of thinking about the disciplines, students’ misconceptions, and use of manipulatives. And these differences are even more significant with a blended approach to content and pedagogy learning. Moreover, we heard that even general education courses might not be well suited to accommodate both mathematics and science teachers’ needs. For example, it was explained that science teachers need to know classroom management skills that are not necessary for their mathematics counterparts, such as managing laboratory equipment.

Some respondents observed that mathematics is taught through established learning progressions from grade to grade across mathematics content areas and suggested that those progressions may make preparing mathematics teachers a more straightforward process. In contrast, in secondary school, multiple discrete science courses are seemingly less connected. In addition, one respondent argued that the body of knowledge taught in school mathematics is generally stable, while the body of science knowledge is exploding, with significant amounts of new information being discovered in our lifetime. These differences suggest that different approaches are needed for mathematics and science teacher preparation. For example, science teaching might need to focus more on teaching science concepts or learning how to learn science.
Concern was expressed repeatedly about regressing to non-challenging courses in trying to implement a blended approach to content and pedagogy - calculus for teachers, linear algebra for teachers, and so on. Instead, courses focused on future teachers need to be as rigorous as other disciplinary courses. As one respondent commented: “There are no concerns about less-rigorous specialized courses for engineers or pre-medical students, but there is an historical problem with less-rigorous courses for teachers.” Instead, student teachers need different kinds of courses that enable them to unpack the content so that they can learn how to teach it. Said one respondent: “If you want to build a quality program from the ground up, both education and disciplinary faculty will all sing from the same hymnal that we respect you, we believe you are capable, we want you to work hard, and we have high expectations.”

Many respondents commented that teacher candidates must learn with and from K-12 master teachers in the disciplines, and that teachers-in-residence must be included as members of the college faculty. In addition, a teacher education program must be a motivated and sustained partnership between faculty who have a responsibility for the pedagogical side and faculty who have a responsibility for the disciplinary side. As one focus group member said, “Neither should have the hubris to say they can go it alone.”

3. How important are out-of-classroom experiences for teacher candidates?

**CONSENSUS STATEMENT 3.3:** Out-of-classroom experiences help teacher candidates gain an understanding of the nature of the discipline beyond what they can acquire in classes.

There is considerable interest and effort nationwide in providing practicing teachers with summer experiences in research laboratories or workplace environments in order to remain connected to their science disciplines and communities, as well as to learn how science knowledge is applied in the workplace. Such experiences help teacher candidates and practicing teachers gain an understanding of the nature of the discipline beyond what they can acquire in classes. Some noted that mathematics teachers would benefit from out-of-classroom experiences as well. One respondent commented that she would have loved to have had the opportunity during her preparation program to experience how mathematics was applied in the real world, e.g. what it means to be an actuary, an accountant, a social science analyst, a statistician, or an architect.
4. How can connections across education and disciplinary departments be strengthened?

CONSENSUS STATEMENT 3.4: Education and disciplinary faculty, along with master teachers and teachers-in-residence, need to create strong partnerships.

Respondents commented that preparation programs should focus from the beginning on integrating the knowledge of the disciplines with how to teach that knowledge to K-12 learners, and noted that this approach will require active support for this vision from the highest levels of university leadership. (Note that A·P·L·U's SMTI is striving to achieve exactly this goal of leadership commitment.) One chemistry focus group member went further, commenting: "We are appallingly bad at making cross-disciplinary connections. Students don't understand how their courses relate to one another. They take other science courses, but if you ask them about the importance of chemistry to biology, or how chemistry can be used to solve questions about fundamental biology, there are no connections. Investigative, inquiry experiences help to make these cross-disciplinary connections."

Different respondents noted varying levels of receptivity among faculty towards reform of teacher preparation programs. Several saw resistance to change from education faculty; others saw disciplinary faculty still actively discouraging their more successful majors from choosing teaching as a career option. All agreed that if the STEM pipeline is to be strengthened beginning in the lowest grades in school, disciplinary faculty need to encourage more of their successful students to become teachers. Again, it was urged, top university leadership must encourage this too.

There was concern that education-disciplinary connections often are too dependent on individuals who may then leave the institution or change focus, thus causing the collaboration to fall apart. Some institutions are grappling with this issue head-on through establishing tenure-track or tenure-equivalent permanent positions for teaching faculty or lecturers with security of employment for those who work directly in teacher education.3

5. How do programs address state and district demand for broad-field science certification versus more in-depth single disciplinary science certification?

CONSENSUS STATEMENT 3.5: No matter the discipline of training, teachers need to be able to make cross-disciplinary connections in their teaching.

General versus disciplinary certification in the sciences concerned respondents. Of particular concern was the disparity in access to well-taught high-school physics courses. But one

3 A study of faculty collaboration and the role of disciplinary brokers as key actors in bridging the education-disciplinary faculty worlds was undertaken as part of this NSF grant (Bouwma-Gearhart, Perry and Presley, 2012; Bouwma-Gearhart, 2012.)
physics focus group participant argued that general science certification could be positive, by
pushing physics (in this example) to interact more with other disciplines in helping students
prepare for general science certification. “You actually understand physics better,” he said.
This comment is related to an earlier one regarding faculties’ general lack of facility in
making cross-disciplinary connections, and that disciplinary silos within universities may be
limiting the emergence of new teacher preparation models to address the reality that science
(and mathematics) teachers often teach multiple subjects year after year.

Respondents in several of the disciplinary focus groups went further, noting that there is not
an agreed upon theoretical base that underpins science education and that this lack is a real
impediment to training science teachers who usually teach multiple science subjects. (Note
that the NRC’s A Framework for K-12 Science Education (National Research Council, 2012)
should go a long way to helping with this issue.) The chemists went further and argued that
chemistry education research focused on content knowledge for pedagogy is in its infancy,
lagging considerably behind mathematics.

In addition to the lack of a useful common theoretical base for teaching the sciences (or
even within science disciplines), respondents commented that there also are rarely enough
programmatic or institutional resources to offer discipline-specific pedagogical courses. One
interviewee reported on a university program where the capacity to run separate life and
physical-sciences pedagogy sessions depended on enrollments. Even within mathematics
programs it is sometimes challenging to offer the range of differentiated pedagogical courses
that are most desirable (and recommended by the Conference Board of the Mathematical
Sciences’ draft The Mathematics Education of Teachers II (CBMS, 2012)). Several respondents
suggested that progress would be enhanced if there were a movement towards common
curriculum development for science and mathematics teacher preparation, rather than
expecting each program, or even each faculty member, to figure it out. And the idea was
raised of developing specialized curricular modules that could be used across the country
or offered on a regional basis to increase access to specialized courses by teacher candidates
enrolled in smaller programs.
Theme #4: Evaluation and Research to Improve Teacher Preparation

CONSENSUS STATEMENT FOR THEME #4: There is a need for ongoing evaluation within programs, and better research to inform the design and development of teacher preparation programs.

Responses fell into four major categories:

1. What are the major goals of program evaluation?
2. What research urgently needs to be done?
3. Who will do that research, and how?
4. How can research findings be communicated to users for action?

1. What are the major goals of program evaluation?

CONSENSUS STATEMENT 4.1: Continuous evaluation of every phase of teacher preparation programs, including strength of school partnerships, is essential for their ongoing improvement.

There was general agreement that teacher preparation programs need to engage in formative self-evaluation. Faculty can learn how to improve their programs by collecting data that monitor the progression of their teacher candidates all the way through the program and at least into their early years of teaching. They can then use those data to evaluate program strengths and weaknesses. In addition, at a minimum, all programs need to be able to assess whether or not their students are growing in content knowledge, teaching skills, and interest in teaching as they progress, and whether or not they become successful teachers, and for how long. However, there must also be professionally agreed-upon high standards for what constitutes program effectiveness, along with the development of better predictors of teacher effectiveness. The current approach, in which individual programs, or even consortia of programs, design their own unique methods will not lead to consistent widely-used standards for measuring program quality, nor will it allow for inter-institutional benchmarking of program success. It was suggested that programs’ self-evaluations could be harnessed for collective use. Through such a project, researchers could build sets of program evaluations for comparative research to inform program improvement.

There was general agreement that the ultimate metric ought to be K-12 student learning outcomes, but the current metrics of student understanding do not provide all the
information needed. There was no support among respondents for value added measures (generally understood as one year of growth as measured by annual state tests) as an appropriate measure of individual teacher and program effectiveness. Instead, respondents spoke of teachers’ need to know more about, and thus programs needing to have better ways of measuring teachers’ understanding of:

- how school-age students think,
- how they see relationships between ideas,
- how they see the relevance of mathematics or science,
- how they are consumers of mathematics and science, and
- what their attitudes are toward science and mathematics.

Respondents also spoke of the need to understand how to link gains in student learning and engagement to teachers’ efforts in the classroom and in their preparation.

There is an urgent need in the United States for preparation programs to be able to demonstrate that they are preparing competent novice teachers. Neither policy makers nor programs can wait for long-term evaluations, although respondents claimed such work still should be attempted. Instead there is a growing body of knowledge regarding intermediate measures of high-leverage practices and characteristics that correlate to K-12 student learning. Such knowledge can be used to identify which teacher candidates are and are not demonstrating the competencies that will lead to effective teaching. The edTPA, for example, holds potential for measuring both teacher competency for formative program assessments and, through aggregation, for program accountability (AACTE, 2012). The work of Deborah Ball and colleagues (Ball and Forzani, 2011; Charalambos, Hill and Ball, 2011; Hill, Sleep, Lewis, and Ball, 2007) and Teach for America (Griggs, 2010) also holds promise for identifying predictors of teaching success.

2. What research urgently needs to be done?

**CONSENSUS STATEMENT 4.2:** We need to know much more about what constitutes effective practices both in teacher preparation and in the K-12 classroom, and how to measure them.

**Research to improve teacher preparation instruction and program design.** Much more empirical evidence of effective instructional practice in teacher preparation is needed, with a focus on the what, how, and when of teacher preparation. For example, we need to know the optimal time that should be devoted to clinical experiences, as well as the scope and sequencing of field experiences. It was noted that these are not yet settled questions.
Work also needs to continue on developing best practices in the transmission of pedagogical content knowledge, and how to translate the new common standards in mathematics and the science framework into recommendations for adoption by mathematics and science teacher preparation programs.

**Research to improve predictive measures of effective teacher performance.** Researchers need to build on current research on effective practices at the K-12 level. Predictive measures of effective performance need good constructs and a common vocabulary for identifying good teaching practices in both mathematics and science. With good constructs and a common vocabulary, different models can be developed for teaching practice, then tested and validated in a variety of local realities. This strategy does not imply that all studies need to be randomized controlled clinical trials, rather that different models can emerge from common constructs.

**Research on standards of performance and quality of novice teachers.** There needs to be a stronger and more applied research base on which to form a consensus around standards of performance and quality of beginning teachers. Consensus that is not based on research results is not particularly useful. However, consensus based on solid research findings is both useful and needed. (Again, we note the promise of edTPA to address this need (AACTE, 2012).)

**Science teaching.** Several interviewees felt that research is needed to develop the basic concepts for teaching science across disciplines. The recently published A Framework for K-12 Science Education (National Research Council, 2012) presents just such crosscutting concepts, science and engineering practices, and core ideas. Perhaps it provides a blueprint that could drive research to translate these concepts into precepts for science teacher preparation across the four major science disciplines (physics, chemistry, life sciences, earth and space sciences).

**Some specific proposals:** Three respondents proposed somewhat similar models of large-scale comparative research. Two involve recruiting multiple institutions to undertake long-term comparative studies to overcome the current gap between theory and practice. To examine program variation, one proposal would be designed with planned variation around a set of core pre-service programs. Another would strive for as valid a comparison as possible among naturally occurring variations in science and mathematics teacher preparation across the United States and internationally. A third comparative approach is currently being explored by one foundation. Here, cohorts of different types of students would be constituted and exposed to different program design approaches, while evaluative data would be collected to identify what works for which types of students.
3. Who will do that research, and how?

**CONSENSUS STATEMENT 4.3:** Too few education researchers undertake research that will produce results that are directly applicable to teachers and classrooms, and there are too few doctoral programs that produce the kinds of researchers needed to conduct such research.

Faculty members in teacher preparation programs are often expected to undertake research, but there is concern that much of their research output has little to no generalizability or impact on K-12 classroom practice. Respondents called on education faculty to do research that solves real educational problems, similar to engineering research, instead of continually identifying problems and dilemmas. But currently, most faculty often only have access to small data sets and too little funding to engage large numbers of teachers and schools in the kinds of robust, long-term research projects that are needed. Yet such projects are the ones that might matter and directly affect classroom practice.

Respondents generally agreed that in order to study the quality of teacher preparation, large-scale studies using large data sets are needed. However, a number of respondents added that it is not appropriate to strive to conduct randomized controlled studies on teaching and learning in school settings. Today, economists and non-profit research organizations, or a handful of faculty teams in a few institutions, conduct most educational research using large databases. There was a call for leadership (undefined) to support more faculty to engage in mining these larger data sets and focusing on the kind of programmatic research that will be of greatest use to the profession. But an additional challenge is the lack of training of most education faculty to undertake this kind of research, or the capacity of doctoral research programs to produce appropriately trained Ph.D.s.

4. How can research findings be communicated to users for action?

**CONSENSUS STATEMENT 4.4:** While there is no one best structure for science and mathematics teacher preparation, what is known about attributes of successful program components needs to be communicated faster and more clearly.

There was general agreement that while there is no perfect design for science and mathematics (and all) teacher preparation programs, evidence already exists and continues to emerge that suggests how various program components might best be configured. Such information needs to be communicated faster and more clearly to a much larger community of users. However, the large number of journals that publish studies on teacher preparation, and the lag between submission and publication of articles, makes it difficult for the average program (or researcher, or policy maker) to keep abreast of the most relevant work that meets specific needs or advances the field overall.
Ten Key Questions University Leaders Should Ask

These consensus statements demonstrate that there is considerable agreement among a broad spectrum of experts across the nation with regard to what it takes to prepare high-quality teachers. There is a strong foundation of agreement upon which strategies for action can build. But what was quite different from the current search for post-preparation evidence of teacher quality was a call for continuous quality improvement processes that examine every step along the pipeline of teacher preparation. Evaluation in this context is conceptualized as an ongoing formative process that each and every program should be practicing on a continuous basis. Teacher preparations programs must be held accountable for the performance of their newly certified teachers, perhaps through a nationally applied approach such as edTPA (AACTE, 2012). But in a continuous improvement model, this is not an after-the-fact judgment of quality, but instead a point along the teacher preparation pathway from recruitment through preparation and into practice.

The four thematic briefs were the basis for conversations for an invitation-only colloquium held April 22-23, 2012 in Boulder, Colorado. Each of the interviewees and one or more members of the focus groups were invited to participate in the colloquium. The purpose of the colloquium was to engage the participants in a deeper discussion going beyond the original protocol questions and into questions of implementation. The Boulder Colloquium participants were asked to further explore attributes of quality programs, those real and imagined, that could routinely produce reliably capable beginning teachers and how those program quality attributes might be developed and supported. A full description of the process used to elicit discussion regarding the four themes is contained in Appendix B.

We began this project intent on identifying key attributes of quality teacher preparation programs. In addition to our confirmation that there is a strong foundation of agreement upon which strategies for action can build, and the importance of continuous formative evaluation, we were also able to draw upon all of the data gathered from interviews, focus groups, and the Boulder Colloquium to craft a list of ten key questions that can guide college and university leaders, and others wanting to gain insight into the quality of teacher preparation programs under their purview. It is the authors’ hope that institutional leaders and others responsible for ensuring that preparation programs produce competent novice teachers will use these questions to guide their quest for quality in their teacher preparation programs. In a companion paper (Coble, 2012b), these ten questions have been mapped to the Goals, Objectives and Strategies of the Analytic Framework. This provides some practical guidance for implementing or improving these program practices.
Ten Key Questions University Leaders Should Ask About Quality Science and Mathematics Teacher Preparation

1. How do you as a leader convey a clear and strong message for the value of quality teacher preparation at your institution? What evidence can you present to affirm your commitment?

2. Does the selection process into teacher preparation programs attract candidates with demonstrated academic success and evidence that they have the skills and dispositions that will likely lead to their becoming good teachers? What data are available to support the response?

3. Are there exit standards beyond minimum state requirements that ensure that the teacher education programs produce competent novice teachers? What, specifically, are the higher exit standards if they exist?

4. Do teacher preparation programs have a culture of evidence and accountability, one that tracks and assesses the progress of teacher candidates from entry to completion and as novice teachers, and uses those data to make appropriate interventions and program changes as warranted? Is a comprehensive assessment plan in place, are data being collected and is there evidence that the data are being used to counsel students and improve the program?

5. Is teacher preparation clinically based, all the way from early classroom exposure, to more extensive, but still well supervised student teaching? Is there a documented sequence of clinical development and evidence of effective monitoring and mentoring by skilled professionals?

6. Do teacher preparation programs blend courses in disciplinary content and pedagogical content knowledge so that students acquire deep content knowledge and the ability to transmit core disciplinary concepts in an age-appropriate way? Is there evidence of such content-pedagogical integration and agreement on its effectiveness by disciplinary and pedagogical faculty?

7. Do programs have vigorous university-school partnerships that demonstrate a shared responsibility for teacher preparation and development with the public schools in which most teacher candidates are placed for clinical experiences and student teaching? Is their evidence that the partnerships are recognized formally and show evidence of sustainability?

8. Are master teachers and teachers-in-residence, those with strong disciplinary backgrounds and evidence of exemplary understanding of teaching, engaged as essential colleagues in teacher preparation? What is the evidence of teacher engagement and the impact of the engagement?
9. Do the teacher education programs ensure that co-operating classroom teachers who are assigned student teachers are master teachers or are teachers under the supervision of a master teacher in the school or district? What is the evidence that selection, preparation and compensation of cooperating teachers assure effective development of teacher candidates?

10. Do the teacher education programs include support to their novice teachers through an induction period as a part of the formal programs? What specific programs of induction support are in place and what evidence of impact is available?

What remains to be done is to build criteria and metrics for assessing the degree to which these strategies are successfully being implemented within programs. This would help programs as they undertake their individual ongoing assessment for continuous improvement, but might also lead to the development of a national competition to recognize exemplary teacher preparation programs.

Concluding Comments

The lack of empirical evidence has not impaired decision-making and program development in teacher preparation. The models and portals of entry into science and mathematics teacher preparation programs continue to proliferate across the United States. And while the authors fully support innovative program design, we also support an adherence to attributes of quality. The creators of programs can and should be guided in their decisions by the research literature that we do have and by the collective judgments of quality by experts with a variety of perspectives on teacher preparation, as we have attempted to do with rigor in this project. In that way, we trust this work will be useful to a wide audience.
REFERENCES


APPENDIX A

Interview and Focus Group Participants

INDIVIDUAL INTERVIEWS

Norman Atkins
Founder and Chairman of the Board of Directors
Uncommon Schools

Deborah Ball
William H. Payne Collegiate Professor in Education and Arthur F. Thurman Professor, Dean of the School of Education
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Bradley Bearden (B)
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Michele Cahill
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4 (B) Indicates the interview respondent attended the Teacher Preparation Quality Initiative Colloquium in Boulder, Colorado, April 22-23, 2012.
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Seeking Consensus on Essential Attributes

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APPENDIX B: METHODOLOGY

The protocol questions

We constructed the protocol questions with the purpose of both stimulating the most creative and heart-felt responses to respondents’ vision of an ideal program as they wished to provide, but also to ask them to go beyond blue-sky comments, by evoking their thoughts about evidence, barriers, research and policy. The interview protocol was shared with the participants only after they had agreed to be included and an interview time and/or focus group meeting was firmly scheduled. Participants were not invited to send written responses to the questions, but simply to engage in the conversation. Clarifying questions were asked, when necessary, by the interviewer to assure that the responses to questions were understood. By prior agreement, we chose not to request taped interviews. Rather the interviews were scripted by the interviewers during the phone call. Focus groups were recorded, but solely for the purpose of helping the interviewers clarify their notes. These were the six questions asked of all:

1. If you could start from scratch, how would you design your ideal science or mathematics teacher preparation program? What would be the most central or critical elements? Are the two areas of science and mathematics different enough that different designs would be preferred? If so, in what respects?

   Prompts, as needed, to stimulate possible responses across the teacher development continuum and in support for teacher preparation:
   • Recruitment, Selection, and Admission
   • Content, Pedagogy, and Clinical Practice
   • Beginning Teacher Support
   • Teacher and School Development (in partnership schools)
   • Leadership, Policy, and Infrastructure
   • Connections with research and researchers on teaching and learning

2. What evidence do you think is critical to support claims of program effectiveness? Regardless of the type of program (undergraduate or graduate) or portal of entry (university-linked or alternative.)

   For these purposes, effective is dually defined as: (a) beginning teacher’s self-reporting of a sense of success and progress in teaching and being observed, and reported by supervisors and/or principals to be a successful beginning teacher; and (b) showing evidence of student engagement and learning across gender, racial, ethnic and economic groups.
3. What research evidence is most important to generate in the near future regarding the effective preparation of beginning teachers of science and mathematics—or teaching in general?

4. How can teacher preparation reduce the wide variability in outcomes, even within the same institution, and produce more consistently effective graduates?

5. What do you consider to be the most critical challenges or obstacles to improving preparation, especially in science and mathematics teachers?

6. And finally, if you were all-powerful, what changes would you promote in state and/or federal policy to ensure that teacher preparation programs produced effective science and mathematics teachers?

Selecting the interviewers

Given the number of people we wished to interview, we knew that it would be almost impossible to conduct all of the interviews ourselves. We also saw it as an advantage to have some carefully chosen interviewers to assist in this effort. We selected people, who themselves could have been on the master list of individuals to interview, but who agreed to assist in the work and follow the protocol and produce a faithful summary of the interviews. Angelo Collins, Ed Crowe, and Donna Gerardi Riordan were selected and agreed to assist in conducting the interviews. The authors conducted all of the focus-group conversations.

Identifying the individual respondents

With input from SMTI staff (Howard Gobstein and Kacy Redd) and the three consultants recruited to serve as interviewers (Collins, Crowe & Riordan), we compiled a master list of 49 persons identified as national/international experts and thought leaders on science or mathematics teacher preparation and teaching from which we selected invitees for an interview. The list included names of highly accomplished secondary science and mathematics teachers, including Presidential Award winners. Leaders from several well-known national alternative programs were also invited to participate in the 60 to 90-minute individual telephone interviews. In addition to the one-on-one conversations, six disciplinary and professional focus groups of four to 13 individuals were convened. Several of the individuals selected from the master list were also identified as persons who would be key participants in the focus groups, so they were not interviewed separately. A very few declined to be interviewed, citing excessive work demands. Others were not ultimately interviewed for various reasons, including international travel, illness - and the inability to schedule the interviews with sufficient lead-time to allow for data analysis leading up to a two-day summative Quality Colloquium held on April 22-23, 2012, in Boulder, Colorado. The final list of 77 individual interviewees (32) and focus group participants (45) is shown in Appendix A.
Identifying the focus groups

The focus groups were based primarily around the science and mathematics faculty disciplines. Considerable effort was given to identifying and inviting some of the most productive and recognized leaders in their discipline who had also been leaders in advancing the K-12 teachers and teaching of their discipline. Each of the disciplinary focus groups also consisted of some faculty who taught science or mathematics pedagogy courses.

In order to undertake face-to-face interviews, we tried to convene groups during national conferences. Focus groups consisted of:

1. A science education focus group, which included faculty whose primary academic responsibility is to teach science pedagogy, was convened in cooperation with the Association for Science Teacher Educators during their annual meeting in Clearwater, Florida on January 5, 2012;

2. An earth and space sciences focus group was convened in a conference call on January 25, 2012;

3. A physics focus group was convened in cooperation with the PhysTEC leadership at the American Physical Society meeting in Ontario, California on February 3, 2012;

4. A mathematics focus group was convened at the annual meeting of the Association of Mathematics Teacher Educators in Fort Worth, Texas on February 9, 2012;

5. A biological sciences focus group was convened in cooperation with the Howard Hughes Medical Institute in Chevy Chase, Maryland on February 29, 2012; and

6. A chemistry focus group was cooperatively assembled with the American Chemistry Society annual meeting in San Diego, California on March 26, 2012.

The 32 individual interviews and the 45 participants in the six disciplinary and professional society focus groups conducted between October 2011 and April 2012 yielded over 150 pages of narrative. We read the reports separately, compiling our own observations before meeting to share our thoughts and discern patterns of general agreement within the narrative and to identify notable outliers.

We were aided in our work by the qualitative analysis conducted by Jana Bouwma-Gearhart who performed an independent analysis of all interview notes first from the individual interviews and then from the six focus groups. Data analysis was predominantly inductive pertaining to the six interview questions. Bouwma-Gearhart used NVivo qualitative analysis software (NVivo, 2012) to first examine the data using an exploratory approach with the goal of identifying general patterns across interviewees’ talk. Factors mentioned by interviewees that seemed to inform interview questions were labeled by NVivo codes and subcodes. Bouwma-Gearhart then engaged in more deductive coding/recoding and analysis to uncover more nuanced patterns in the data.
No distinctive differences in overall response patterns were detected by the analysis of individual and focus group responses, except, not surprisingly, there was more discussion in the focus group interviews about science, technology, engineering, and mathematics (STEM) faculty and departments as agents of change in creating better science and mathematics teacher education.

**The Boulder Colloquium**

The four thematic briefs were the basis for conversations for an invitation-only colloquium held April 22-23, 2012 in Boulder, Colorado. Each of the interviewees and one or more members of the focus groups were invited to participate in the colloquium. Each person invited was provided with the four thematic briefs, plus a list of questions linked to each of the summaries. The purpose of the colloquium was to engage the participants in a deeper discussion going beyond the original protocol questions and into questions of implementation. The Boulder Colloquium participants were asked to further explore attributes of quality programs, those real and imagined, that could routinely produce reliably capable beginning teachers and how those program quality attributes might be developed and supported.

Twenty-four interviewees or focus group members, plus a program officer with the National Science Foundation, were participants in the Boulder Colloquium. The design of the colloquium was to create three small groups, each with an assigned external facilitator and recorder, to discuss questions associated with each of the four themes that were designed to prompt but not direct discussion. The composition of the three small groups was shuffled for each theme over the course of the 30-hour colloquium. The facilitators and recorders were also shuffled for each of the four discussions. The purposeful mixing and matching of participants and staff created the maximum interaction of people and ideas within the constraints of the time we had allocated for the colloquium.

Following small-group-facilitated discussions on the four themes, key statements were posted and explained verbally to the entire group. Other participants could ask the presenting group clarifying questions. Once all three groups’ key points were posted, participants voted on their top priorities (either in importance or for action) by placing dots on their top three across all of the small group presentations for the particular theme under discussion. After repeating this pattern for all four themes, participants had one final vote — their top priorities across all of the four themes. Although it turned out not to be the case, it would have been possible for no items from an entire theme to have been selected as a top priority when in competition for votes across all other themes.
The **ASSOCIATION OF PUBLIC AND LAND-GRANT UNIVERSITIES** (www.aplu.org) is an association of public research universities, land-grant institutions, and state university systems, founded in 1887. A•P•L•U member campuses enroll more than 3.5 million undergraduate and 1.1 million graduate students, employ more than 645,000 faculty members, and conduct nearly two-thirds of all academic research, totaling more than $34 billion annually. As the nation’s oldest higher education association, A•P•L•U is dedicated to excellence in learning, discovery and engagement.

The **SCIENCE & MATHEMATICS TEACHER IMPERATIVE** (SMTI) is an initiative of A•P•L•U and the nation’s public research universities to transform middle and high school science, technology, engineering and mathematics (STEM) education by preparing a new generation of world-class STEM teachers.