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Dear Katie,

Please find attached my submission to the Governor's Commission on Education Reform in New York State, which forms the basis for a presentation at the October 22 hearing in Rochester. I teach until 1115 am, and so I won't arrive until 130 pm.

Thank you for your time and consideration.

Sincerely yours,

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and

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Summary

Maximizing the access of our middle and high school students to high quality science and mathematics education is critical both to their futures and to the future economic development of New York State. Too many of our schools do not offer key courses required for college study in STEM fields. Too many of those who teach these key courses – especially in Physics - are underqualified, and leave their students unprepared for the rigors of college STEM study.

Most NYS colleges that focus on teacher preparation have relatively uncompetitive admissions and attract relatively few students who are strong in the physical sciences, mathematics and technology. Strong STEM students are abundant at our research universities, but these institutions generally provide little or no support for STEM students interested in K-12 teaching careers, and train few teachers.

Any attempt to increase our pool of qualified STEM teachers must focus on our institutions that attract the largest numbers of highly qualified students.

NYS must:

- Tell its research universities that NYS considers training of middle and high school teachers for STEM disciplines a priority that they must embrace.

- Provide financial and other support to these universities to expand their STEM teacher recruiting and training programs, especially programs that are based in university STEM departments rather than in Education departments.

- Develop a state-wide network to allow sharing of resources and best practices appropriate to the research university environment.

- Provide direct financial support to highly qualified students to pursue training in STEM teaching.

The discussion that follows focuses on high school physics and physics teachers, as I am most familiar with issues there, but the situation is similar in mathematics and chemistry. Nationally, these are the three subject areas with the greatest teacher demand. All quoted numbers in the following are approximate, and in some cases are based on incomplete data.

Issues in K-12 STEM Education

The US and NYS have critical shortages of high school physics teachers, and significant shortages of mathematics and chemistry teachers.

- Only 1/3 of all high school physics teachers have a degree in physics or physics education. None of the current physics teachers in relatively affluent and well educated Tompkins County has a physics degree.
- Almost 1/3 of all high school physics teachers have taken two or fewer college physics classes.
- Many NYS school districts have substantial difficulty finding and retaining qualified physics teachers.
- 55% of NYC schools do not offer physics, representing 23% of total enrollment.
- Teacher shortages are most severe in less affluent urban districts and in rural districts.

Physics, chemistry and mathematics are important to socioeconomic mobility and US economic competitiveness.

- All three subjects are prerequisites for nearly all careers in engineering, chemistry, biology, environmental and earth sciences, and the medical and veterinary sciences. These careers are critical to present and future NYS economic competitiveness. Many with physics and mathematics training go on to careers in finance, economics and management.
- These careers are well-paid and well-respected, and historically have provided an upward path for the socioeconomically disadvantaged.
- Not taking high school physics closes more career doors than any other elective high school subject.
- Access to quality high school physics, chemistry and mathematics education is thus an issue of social justice.

Too few US high school students take and succeed in physics and other STEM subjects.

- Only 1/3 of US high school students take physics. This is far less than in most countries with which we compete economically. Many countries require *all* students to take physics. The US would need to increase the number of teachers it trains by a factor of four to match them.
- Physics, more than any other subject in high school, teaches quantitative and analytical reasoning skills that are critical in a 21st century economy. Math is an important tool, but physics makes math "real".

Women and minorities are underrepresented in STEM fields.

- Women are underrepresented by a factor of 2, even though more women now take high school physics than men. African Americans and Latinos are underrepresented by a factor of 4 or more.
- Most leakage from the STEM career "pipeline" occurs in high school and in the transition from high school to college, not in college. Many students who do not / cannot take high school physics never enter the pipeline.
- Engaging, well-prepared middle and high school STEM teachers are critical to providing capable students — and especially women and minorities — with the confidence and interest to pursue STEM degree programs. Poor initial experiences can dissuade and demoralize.
- Highly qualified physics, chemistry and math teachers tend to be hired by wealthy suburban school districts, not by districts in our inner cities and rural areas. Inequality of opportunity in physics education contributes to inequality in college and career outcomes.

How did we get here?

Teacher education programs do not attract students who are strong in STEM disciplines.

- For historical reasons, most K-12 teacher training in the US occurs at Tier II and Tier III colleges and universities. These have relatively unselective admissions and attract fewer students who are strong in STEM disciplines. High school students that are good in math and physics generally have good overall test scores, and are much more likely to end up at Tier I institutions.
- In NYS in 2006-2007, the top 14 of 84 teacher training institutions produced 64% of all physics teacher certifications but only 16% of physics majors. The average Math SAT score for these institutions was 540, corresponding to the 64th percentile of all high school students who take the SATs.

The institutions that attract the strongest STEM students train very few teachers.

- At Tier I universities, physics- and STEM-capable students are abundant. However, teacher recruiting and training programs, which are housed and run outside of the STEM disciplines, often have little visibility to these students or to faculty in STEM disciplines. Education departments generally have weak connections to Physics, Math, Chemistry and Engineering departments.
- At Tier I universities, the institutional ethos drives students toward careers at the frontiers of science and technology, even though most will not end up there. It drives them to become just like their professors - faculty in research universities - even though less than 1 in 50 undergraduate students and less than 1 in 15 graduate students will end up in such positions.
- In NYS in 2006-2007, the top 11 of 84 institutions for training physics majors produced 61% of all majors but only 20% of physics teacher certifications. The average Math SAT score for these institutions was 650, corresponding to the 86th

percentile. The Math SAT score of 600 corresponding to the 25th percentile of admits to these institutionsis larger than the 75th percentile of 590 at the top physics teacher training institutions.

- At Cornell, roughly 1300 undergraduate students per class take an introductory physics sequence, of which roughly 650 are Engineering, Physics and Applied Physics majors. Prior to 2007, on average only one of these students earned Physics teaching certification following graduation. Cornell is typical: most Tier I universities in the US produce 3 or fewer physics teachers per year.
- Most Tier I universities are not even physics teacher neutral: they train and certify fewer teachers each year than are required (given attrition rates from the profession) to ensure that the students who enroll in their introductory physics courses each year have had high school physics.
- The situation in Canada, where most teacher training occurs in Tier I universities, is rather different. The University of Toronto graduates roughly 25 physics teachers per year, or roughly one-third to one-half the total production of all NYS colleges and universities.

Currently available financial aid programs for teachers-in-training are unattractive to our best students.

- The largest program – NSF's Robert Noyce Scholarship Program - requires students to commit to teaching in high needs districts for two years for each year of support. This often means that they must commit to a significantly lower starting salary than they could earn elsewhere, and to working in a school that provides less support and fewer excellent role models. The NSF doesn't place comparable restrictions on its graduate research fellowships. In what other profession do we expect our top students to start at the bottom?

- Our best students should be able to choose where they want to work, and that best supports them in achieving their potential as educational innovators and leaders.

Some suggestions

1. NYS must encourage colleges and universities with the largest and most qualified STEM undergraduate populations to embrace the recruitment and training of middle and high school STEM teachers as a priority.

2. Because of generally weak connections between Education and STEM departments, and because STEM students look to STEM faculty for leadership, teacher recruiting and training efforts should where possible be based in STEM departments, with buy-in from STEM faculty.

3. Teacher training programs should be run and marketed as Professional Masters Programs in Science and Mathematics Education and should be focused on acquisition of specific job related skills and credentials, similar to Master of Engineering programs, so as to maximize their appeal to STEM undergraduates.

4. To encourage exploration of teaching careers and to compete with abundant opportunities for undergraduate research experience, Tier I institutions should provide opportunities for STEM undergraduates to obtain a structured introduction to the intellectual and practical challenges of teaching. The American Physical Society's PhysTEC program (e.g., see phystec.physics.cornell.edu) provides one model for how such activities might be organized and delivered.

5. Money talks, especially at Tier I institutions. NYS should provide financial and other support to these institutions for both undergraduate recruiting and early field experience and for professional Masters programs directed at STEM teacher production. Where possible, this support should be directed to programs in STEM departments rather than Education departments.

6. Funded universities should be required to participate in a state-wide network to allow sharing of resources and best practices and co-teaching of subject-specific pedagogy courses.

7. NYS should offer competitive financial aid for teacher training in high-demand STEM disciplines, with the aid being forgiven if a student completes five years of teaching in any NYS school.

Some Common Questions / Objections

"Students at Tier I institutions aren't interested in teaching."

For example, Cornell has consistently been one of the top sources of recruits for Teach for America.

"Parents aren't going to pay Tier I tuition for their child to become a high school teacher."

Some won't. But most STEM students believe that their parents will be supportive of their choices.

"Why would a STEM student at a Tier I institution choose to go into a low-paying, low prestige profession like high school teaching?"

Students in the top half of any class certainly have better choices. But for the bottom half – still a very talented group – high school teaching jobs in better school districts can compare favorably with their other opportunities.

Salaries may be somewhat lower, but job security and benefits are often better; teaching jobs provide opportunities to explore and enjoy other interests via coaching and club mentoring; in high demand subjects like Physics, teachers can choose

where they want to work, including close to family and friends; and high school teaching careers are much more family friendly.

Physics teachers have the highest job satisfaction of all K-12 teachers. And while the teaching profession as a whole may get a bad rap in the media, good teachers are revered by their students and their communities.

Most STEM students will pursue other careers. But if 3% chose teaching, the STEM teacher shortage would be solved. The low hanging fruit are abundant.

"Why would a talented STEM student choose a dead-end career like high school teaching"

We aren't asking them to spend all 40+ years of their professional lives teaching one subject in one school. We are asking them to consider teaching as one of their careers: as a first career, for a few years after their undergraduate studies, before continuing for graduate or professional studies; as their primary career; or as a second or third career, after working in industry.

We are asking them to gain experience and earn credentials to make a future transition to a teaching career as easy as possible.

We want our best students to become educational innovators and leaders, not just "teachers".

"Why would research universities get involved in STEM teacher training?"

Because of NYS pressure and NYS money.

Because faculty and administrators fret about the lack of diversity in STEM disciplines. The best way to address that lack of diversity is by improving STEM education in our middle and high schools.

Because most research universities already have significant NSF-mandated K-12 outreach efforts. These efforts are largely peripheral to and a distraction from their core missions of undergraduate and graduate student training. Training undergraduate and graduate students to become K-12 STEM education professionals is a much better fit to this core mission, and has synergies that can be exploited to improve the undergraduate instruction of all undergraduate STEM majors.

"Faculty in STEM departments aren't interested in helping train teachers."

Most aren't. But a successful program requires only one or two faculty champions, with most of the work done by non-tenured lecturer-level professional staff.

"NYS has enough teacher training programs. Why don't Tier I universities send their STEM graduates to, e.g., SUNY Cortland to obtain their teacher certifications?"

Because few students who have paid for a Tier I education will want to earn their professional degree from a Tier II or III institution.

Because the caliber of students in those programs is far lower than at Tier I institutions, so that Tier I students will not have appropriate peers.

Because it sends a message that NYS and the Tier I institution considers K-12 STEM education to be a second rate career for second rate students.

Because without a strong teacher recruiting and training program in their own institution, far fewer Tier I STEM students will even consider K-12 STEM education careers.