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DEVELOPING AND SUPPORTING EXEMPLARY MATHEMATICS EDUCATORS IN HIGH NEED SCHOOLS

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In the United States, students in high need school districts generally do not do as well in mathematics as students in other districts, and they are ultimately less likely to become part of the STEM workforce. Addressing this gap requires both the development and the retention of high-quality math teachers in high need districts. In this paper we report on a project, now in its seventh year, to do so. The project features university level math educators and mathematicians working together, allowing for foci on content knowledge, pedagogical content knowledge and expertise in pedagogy as well as the development of a professional community concerned with supporting secondary math teachers. The project has been broadly successful, and our experience provides lessons that may be helpful for other programs with similar concerns.

INTRODUCTION

An increasing number of desirable jobs worldwide require a good knowledge of mathematics, and so it is a matter of fairness that all students in a country be supported in developing such knowledge. In the United States, there are significant gaps in math achievement correlated with race and socioeconomic status (National Research Council, 2011). High need school districts, defined in section 201 of the U.S. Higher Education Act of 1965 (20 U.S.C. 1021), are agencies that enroll a high percentage of low-income students, feature a high percentage of secondary school teachers who teach outside of their trained content areas, or have a high teacher turnover rate. Students in high need districts are less likely than their counterparts to do well on capstone mathematics examinations and to end up in the STEM workforce, while teachers in these districts may face a challenging work environment and may also be less well prepared in the discipline than their counterparts in more affluent districts (ibid). Though we are speaking of the U.S. here, similar considerations are common worldwide. When they do apply, supporting and retaining in-service math teachers in high need schools is of great importance, directly related to equity, to making full use of a country's talents, and ultimately to long-term economic development.

This abridged research report presents the findings of an extensive project, now in its seventh year, whose goal is to develop and support high quality secondary level math teachers in high need school districts in the greater Boston area through their engagement in a systematic professional development program. The project has been a success: we have seen new math teachers enter and stay, teachers with weak content knowledge improve dramatically, and teacher-leaders emerge. The project grew out of a strong, on-going working relationship between university level mathematics educators (Albert) and mathematicians (Cheung, Friedberg), a relationship based on a common appreciation of the importance of the task at hand, an awareness of our complementary intellectual backgrounds and

genuine mutual respect. Our results demonstrate the value of applying multiple areas of expertise to the problem of math teacher support at the secondary level. This project has taken place in an urban area that is rich in intellectual capital, and our program has also drawn upon this, featuring the involvement of area non-profits concerned with education (the Education Development Center, Math for American Boston) and an area program to develop teacher content knowledge (*PROMYS for Teachers*). Below we describe our program and its results. Then, drawing upon our experiences, we offer key lessons learned concerning the programs for the support and retention of teachers in high need schools that could be applied broadly. Our project has been supported by a grant from the National Science Foundation (DUE-1339601).

PROGRAM GOALS AND GUIDING PRINCIPLES

The program was designed to accomplish two complementary goals. One was to encourage new teachers to join the profession, teach in secondary schools in high need districts, and to retain these teachers through their first four years of teaching (the period when they are most likely to leave). The teachers in this group entered our program after finishing their Bachelor's degree in mathematics or mathematics education. The second was to provide a pathway to excellence for a group of experienced secondary math teachers in high need districts who already had their Master's degrees. Though most of their Master's degrees were in mathematics education, these teachers did not all have an undergraduate degree in mathematics. For example, one majored in music therapy.

Since good teaching requires strong content knowledge, pedagogical content knowledge, and pedagogy (Shulman, 1986; Ball, D. L., Hoover Thames, M. & Phelps, G. 2008), we have been concerned with all three. We kept content and pedagogy related to secondary math as a central focus, as schools themselves would provide professional development opportunities that were cross-disciplinary. We also recognized that success in teaching in a high need environment requires a high level of cultural awareness. And we valued and strove to create a community centered around secondary math teaching, a space where the teachers in our program, who taught in different schools and districts, would come together as math teachers pursuing professional growth.

PROGRAM STRUCTURE AND RESULTS

There were eight teachers in each group, selected through a competitive admissions process. The beginning teachers applied to the Master's degree program at Boston College's Lynch School of Education and Human Development (LSEHD), while the experienced teachers applied directly to the program. The selection process for the experienced teachers included being asked to solve and discuss several non-standard problems requiring secondary math, and some found those problems very challenging. Each participant made a five-year commitment and received a stipend provided by the grant during those five years.

The new teachers spent their first year and surrounding summers pursuing coursework leading to a Master of Science in Teaching degree. The coursework included courses that developed their mathematics expertise related to secondary math and courses in education, including courses that focused on urban teaching and on teaching bilingual students. These teachers were required to attend *PROMYS for Teachers*, a summer program at Boston University (a different institution than Boston College; both are research universities) that focused on math content knowledge, and upon graduating

they were supported through the induction program provided to all LSEHD graduates entering the teaching profession. During their first four years of teaching they attended *PROMYS for Teachers* workshops run by our non-profit partner the Education Development Center, attended a monthly Mathematical Practices seminar run jointly by BC faculty and our other non-profit partner Math for America Boston, and attended a quarterly Math Education Colloquium at BC. They also received extensive mentoring, by both a mathematician and an experienced teacher in our program, that included classroom visits and follow-ups.

The experienced teachers were asked to take one pre-approved course at Boston College each year, something that was useful in extending their knowledge and that could also result in a salary increase from their school. They also attended the *PROMYS for Teachers* workshops and the Math Education Colloquium, and participated in the Mathematical Practices seminar. They had classroom visits by a math professor for content mentoring, while serving as a teaching mentor to a new teacher in the program. They also undertook a year-long project in small teams to address a selected issue in math teaching, contributed to the pre-service program at Boston College, and as a final project organized a workshop or mini course at their school for their colleagues there. Also, as the program progressed, the teachers themselves took increasing responsibility for the Mathematical Practices seminar, and some ultimately worked with school districts and Math for America Boston to design and organize a professional development program.

Teachers in both groups were offered funding to attend conferences and professional meetings. While there was surprisingly little enthusiasm for this at first, by the end a number of teachers had taken advantage of this opportunity and found it to be a valuable experience. Also, the importance of content preparation for high-quality teaching in mathematics is well-documented (National Research Council, 2000). If teachers in either group needed additional sustained support concerning content, this was handled one-on-one by taking an independent study course supervised by a BC math faculty member.

The program results are striking. Seven of the new teachers have continued teaching in high-need school districts, and three have already been promoted to Chair of their school math department. One reports that she would not have stayed in teaching without this program. Their teaching has developed and we can see clear signs of strong math knowledge for teaching. Seven of the eight experienced teachers remained for five years; another left to become a Headmaster (in the same high need district). One of the teachers who remained has since become his school's Vice Principal, another her school's math department Chair. Like the new teachers, the experienced teachers have demonstrated an increased math knowledge for teaching. Many teachers reported that our program gave them content-based professional development that was absent in their own school, allowing them to increase their connection with math and maintain their enthusiasm for it. The participants reported high satisfaction with the program.

LESSONS LEARNED AND IMPLICATIONS

As with any complicated program, there were some surprises. Mentorship skills were not automatic, even for experienced teachers or faculty, and it took some effort and thought to develop them. Speakers, even academics in math education, needed guidance—they were most successful when we asked them specifically to be mindful of the teachers in the audience. New teachers focused on

classroom management and became more enthusiastic about discussing math content only after they had solidified their management skills. Coordinating all the different parts of our program was a substantial effort.

Our experiences suggest the following key lessons for in-service support for secondary math teachers:

- Teachers benefit from rich content experiences that use or build on secondary school level mathematics. In fact, teachers may not find opportunities for serious on-going engagement with math content in their school systems and are likely to appreciate the opportunity for such engagement. Such experiences can be core parts of a support program.
- Math education faculty and mathematics faculty members each have expertise that is important in supporting secondary math teachers, and a project that involves both will add value to teachers in multiple ways.
- Teachers are concerned with content, pedagogical content knowledge and pedagogy. Providing a balance of math experiences and opportunities to discuss pedagogy is helpful. Sometimes leadership is necessary to move from the discussion of day-to-day pedagogical concerns to a wider perspective.
- Surprisingly, even experienced teachers benefit from mentoring; however, providing such mentoring is a skill in its own right, and not all experts are good mentors.
- A sustained program of professional involvement is a good platform for leadership, providing a pathway for teachers to take more responsibility and ownership over time.
- The value of being part of a community of math professionals, even a community spanning a number of different school districts, is high.

With the cost of replacing a teacher leaving an urban school district at greater than $20,000 and shortages in math teachers, particularly in high need schools (Carver-Thomas & Darling-Hammond, 2017), a program such as this one has the potential to make a significant difference. To be clear, some important aspects of our program are not easily duplicable; for example, the teacher stipends required substantial funding. Nonetheless, the key points noted above are likely to be useful in many other settings. We must seek to build and systematically support communities of exemplary math educators.

References

Ball, D. L., Hoover Thames, M. & Phelps, G. (2008). Content Knowledge for Teaching What Makes It Special?. *Journal of Teacher Education*, 59(5), 389-407.

Carver-Thomas, D. & Darling-Hammond, L. (2017). *Teacher turnover: Why it matters and what we can do about it*. Palo Alto, CA: Learning Policy Institute.

National Research Council. (2000). *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*. Committee on Science and Mathematics Teacher Preparation, Center for Education. Washington, DC: The National Academies Press.

National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. Committee on Highly Successful Science Programs for K-12 Science Education, Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences Education. Washington, DC: The National Academies Press.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.