Recruiting, Preparing, and Retaining STEM Teachers for a Global Generation

Jacqueline Leonard, Andrea C. Burrows and Richard Kitchen (Eds.)

There is a critical need to prepare diverse teachers with expertise in science, technology, engineering, and mathematics (STEM) with the skills necessary to work effectively with underrepresented K-12 students. Three major goals of funded STEM programs are to attract and prepare students at all educational levels to pursue coursework in the STEM content areas, to prepare graduates to pursue careers in STEM fields, and to improve teacher education programs in the STEM content areas. Drawing upon these goals as the framework for *Recruiting, Preparing, and Retaining STEM Teachers for a Global Generation*, the 15 chapters contained herein highlight both the challenges and successes of recruiting, preparing, and sustaining novice teachers in the STEM content areas in high-need schools.

Recruiting, retaining and sustaining highly-qualified teachers with expertise in STEM content areas to work in hard-to-staff schools and geographic areas are necessary to equalize educational opportunities for rural and urban Title 1 students. High teacher turnover rates, in combination with teachers working out-of-field, leave many students without highly-qualified teachers in STEM fields. Most of the chapters in this volume were prepared by scholars who received NSF funding through Noyce and are engaged in addressing research questions related to these endeavours.

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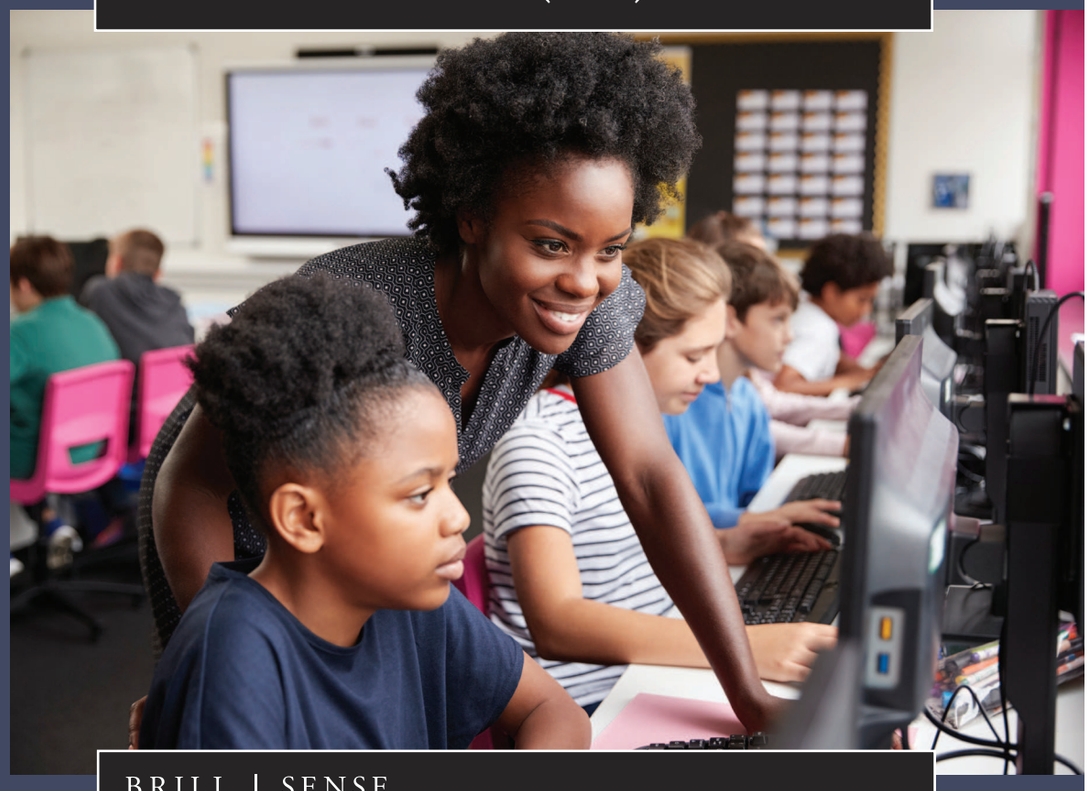

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Contents

Preface

There is a critical need to prepare teachers with expertise in science, technology, engineering, and mathematics (STEM) with the skills necessary to work effectively with K–16 students from diverse backgrounds. Kuenzi (2008) reported on more than 200 federal grant programs in STEM education and found that three major goals of these programs were to: (a) attract and prepare students at all educational levels to pursue coursework in the STEM content areas; (b) prepare graduates to pursue careers in STEM fields; and (c) improve teacher education programs in the STEM content areas. Drawing upon these goals as the framework, the 15 chapters contained in *Recruiting, Preparing, and Retaining STEM Teachers for a Global Generation* highlight challenges and successes in K–16 educational settings. Several scholars received funding from the National Science Foundation's (NSF) Robert Noyce Scholars program, while some received funding from other agencies, to examine the recruitment, preparation, and retention of STEM teachers and educators in rural, urban, or international contexts.

This volume is organized into three primary parts: (1) teacher recruitment in the STEM content areas, (2) teacher preparation in STEM education, and (3) STEM teacher mentoring and retention. The descriptions of each chapter are provided by part. We begin by summarizing the first four chapters in the book on teacher recruitment.

Part 1: Teacher Recruitment in the STEM Content Areas

In the volume's first chapter by Leonard, Chamberlin, Aryana, Lazic and Even, preservice teachers' self-efficacy in STEM and mastery experiences after a summer internship experience are discussed. Using journal entries and field notes to complete the Dimensions of Success Tool, participants (predominantly female, European-American undergraduate students in STEM disciplines) reported positive effects of the summer internship program. Specifically, participants generally suggested that the summer experience helped raise cognizance of areas of need in future elementary education preparation. In short, the summer internship was deemed valuable by participants.

In the second chapter, Eli, McGraw, Anhalt, and Civil describe the work of the Arizona Mathematics Teaching (MaTh) Noyce Program that focuses on recruiting and preparing undergraduates who have expressed interest in secondary mathematics teaching. The purpose of the program is to help the undergraduates develop mathematically rich experiences for all students

in grades 6–12, particularly those from culturally and linguistically diverse backgrounds. The program is a collaborative model involving a community of mathematics education faculty, undergraduates, teachers, and secondary mathematics students and their communities. In this chapter, the authors describe a collaborative model for providing opportunities for prospective secondary mathematics teachers to learn about and implement equitable teaching practices. They found three overarching themes influencing participants' inclination to learn about and engage in equitable teaching practices through Noyce Program activities: (a) experiencing teaching opportunities; (b) building relationships; and (c) developing professional identities grounded in equity.

The recruitment and retention of Black STEM teachers is a nation-wide challenge for the field of teacher education. In their chapter, Johnson, Dunleavy, and Joseph start to unpack the recruitment and retention challenges of Black teacher candidates into Vanderbilt's Noyce STEM teacher education program. They share the analysis of lived-experience interviews from two Black teacher candidates who earned their STEM degrees from an HBCU (Fisk University) and then transitioned to a PWI (Vanderbilt University) to earn their Master's degree in Education (M.Ed.). The analysis of their lived experiences revealed four themes: (a) the need for more visible partnerships between the HBCU and PWI; (b) the identification of mentors for scholar success; (c) the investigation for understanding Black teacher candidates as role models for their students; and (d) the institutionalized racism that still challenges Black teacher candidates at PWIs. These findings have implications for how programs situated within a PWI might consider the recruitment and retention of Black mathematics and science teachers.

In the final chapter on STEM teacher recruitment, Ogodo, Irving, Brosnan, and Ding describe how teaching in urban high-need schools can be challenging for teachers, which is one major reason for high teacher turnover. Inadequate teacher enculturation can also contribute to high teacher attrition. The Empowering Noyce Apprenticeships by Leadership Engagement in STEM Teaching (ENABLE STEM) project is a study funded by the National Science Foundation (NSF) that is designed to recruit students into the Master of Education program at The Ohio State University (OSU) with the goal of empowering them to become successful learners and productive innovators in STEM fields. OSU preservice teachers are prepared as quality teachers, empowered to *rise* and *defy* the challenges that prevent others from remaining in urban high-need schools. They are equipped to *teach* students effectively through a four pronged-focused and intensive teacher training program: (a) Urban Teaching Seminar; (b) informal teaching experience at the Center of Science and Industry; (c) science methods with scientists and science educators; and (d) *leader*ship focused induction and mentoring.

Part 2: Teacher Preparation in STEM Education

In the first chapter of this part, Edwards, Williams, Kuhel and Epps describe how a professional development project engaged mathematics preservice teachers and teacher educators in an ongoing conversation about teaching culturally and linguistically diverse students enrolled in high-need schools. Qualitative research methods were employed to examine preservice teachers' perspectives about the process of learning to teach culturally and linguistically diverse students and how their identities and cultural competence evolved as they progressed through five professional development workshops and a semester long clinical field experience in an urban high-need school.

In the next chapter, White, Leonard, Chamberlin and Buss write about how high teacher turnover rates and teachers working out-of-field leave many children in rural and urban contexts without a highly-qualified teacher. The Robert Noyce Scholars program was instituted to address this problem in STEM education. The Wyoming Interns to Teacher Scholars (WITS) program was developed to increase the number of STEM teachers in rural K–6 settings. This chapter examines how professional development and other supports influenced self-efficacy in mathematics between two cohorts of Noyce scholars and the student teaching experiences of three Noyce scholars' in mathematics. Results of the Mathematics Teaching Efficacy Belief Survey (MTEBI) were mixed. Preservice teachers' self-efficacy and outcome expectancy scores were malleable but vacillated slightly over time. Male preservice teachers' scores were higher than female preservice teachers' scores on self-efficacy and outcome expectancy. However, observational data revealed strong evidence across all domains that focal student teachers' mathematics lessons improved over time. Student teachers who attended professional development and incorporated supervisor's feedback showed the most improvement. However, additional research that links professional development to advances in preservice teachers' mathematical content knowledge and pedagogical content knowledge is warranted.

Campbell and Heller argue in their chapter that while the importance of teaching computational thinking has received national attention over the last decade, many educators continue to lack the understanding and awareness to implement computational thinking as a problem-solving framework in their daily instruction. In their mixed methods study, preservice teachers participated in *Pop-Up Makerspace* activities designed to introduce and explore computational thinking as a framework for problem solving. After determining the participants' level of confidence teaching STEM-related content was lowest in problem-solving and engineering, the study examined how affective factors such as disposition and attitude were evident during the *Pop-Up* learning

experiences. In this study, educators demonstrated the affective traits of resilience, failure, persistence, and frustration. Each factor of computational thinking was observed during the design and making experience. The effects of participation in a *Pop-Up Makerspace* motivated the preservice teachers to incorporate these experiential learning experiences into their own teaching practices.

In the next chapter, Ziols considers some of the complexities and challenges in STEM teacher education with respect to recruitment, preparation, and retention. First, STEM teacher education is considered from a "race-centered" political economy perspective. It is argued that a "race-centered" political economy perspective on STEM teacher education may provide an important lens for examining how both "traditional" and "alternative" teacher education programs approach issues of recruitment and preparation. Next, drawing from Rancièrean political theory, STEM teacher education is considered with a different sense of the political. Dropping retention concerns from teacher preparation program planning is provided as an example of a less familiar framing of the political that may offer alternative ways for approaching perennial and endemic issues in STEM teacher education.

In the final chapter of the part, Irving, Pradhan and Nahar describe how the global community is engaged in educational reform to improve opportunities for young people in higher education and scientific research. The responsibility of science teacher educators extends to the preparation of world-class faculty in STEM disciplines at institutions of higher education (IHE). This chapter describes a highly intensive and innovative international dual-degree program designed to prepare world-class professors in STEM fields for colleges and universities. With about 150 million future students, some reports indicate that 50,000+ new colleges and universities are being formed in India. These new institutions of higher education need highly-qualified STEM faculty to train the next generation of leaders in STEM fields. A collaboration funded by the US-India Education Foundation (USIEF) between The Ohio State University (OSU) and the Aligarh Muslim University (AMU) was established with the primary goal of exploring pathways to prepare the next generation of world-class STEM faculty for universities in India. Theoretical frameworks and logistical challenges are described.

Part 3: STEM Teacher Mentoring and Retention

The final part of the book includes six chapters. The first three chapters focus on mentoring and induction, and the final three on retention. In the first chapter, Segura et al. examine how teaching that is oriented towards equity

and social justice was co-constructed between two experienced high-school science teachers and their four student teachers. Using the lenses of structure-agency dialectic and culturally responsive mentoring, along with case study design, we studied ways in which structures (e.g., curricular, pedagogical, material, symbolic, and programmatic) influenced, and were influenced by, the experienced teachers' and their student teachers' agency to conceptualize and enact such practices. The findings unpack the complicated nature of learning to teach science in ways that promote equity and social justice. The cooperating teachers' mentoring was structured differently based on how each interpreted the structures impeding their students' agency. Moreover, the student teachers constructed their cooperating teachers' guidance differently, using their own agency to support student agency. Although the teachers and student teachers foregrounded specific dimensions of culturally responsive mentoring, other dimensions of the framework intermingled to inform and shape the practices of experienced and novice teachers.

The major objective of the study described in Albert's chapter is to document the experience of eight beginning teachers, eight experienced teachers, and six mathematicians participating in a professional learning community. The hallmark of the professional learning community is a two-way mentoring model, designed to incorporate content and pedagogical knowledge for teaching mathematics, whereby the beginning teachers have a mathematician and an experienced practicing teacher as mentors. Applying Vygotsky's concept of sociocultural historic theory, the mentor-mentee relationship is examined through the lens of intersubjectivity. Findings suggest that the development of intersubjectivity can move the mentoring process ahead, where this relationship is characterized by achieving a common understanding of mathematical activities and ideas.

In the next chapter, Barnes-Johnson, Aryana and Leonard report findings from a Noyce study on the internship experiences that supported STEM undergraduate students' transition to elementary teaching in a rural, high-need context. The central research question addressed in this chapter is how can pre-professional mentoring and Noyce programs be used to support STEM majors to become equity-minded STEM educators? An underlying assumption embedded in this question is that teachers who espouse equity as a guiding principle for teaching will be more committed to teaching in high-need contexts, a requirement for participation in the Noyce scholarship program. This chapter reports on training experiences provided to Noyce scholars at various stages of commitment to the two- to three-year program. The identity development of a mentor and three interns were explicated as a cross-case study of a Noyce scholars' program. The patterns of support that improved self-efficacy and cultivated equitable STEM teacher identity development may be

used as a model for STEM teacher preparation programs in other high-need communities.

In the first chapter focused on retention, Burrows describes a study that targeted degree holding STEM graduates to support licensure and induction in secondary science or mathematics. The project, entitled Sustaining Wyoming's Advancing Reach in Mathematics and Science (SWARMS), provided the study's pool of 24 participants. This chapter highlights the SWARMS chat room to document the study's successes and challenges as well as the participants' interactions. Throughout the four-year study (2014–2018), qualitative and quantitative data showed consistent chat room interactions, especially as these data relate to classroom activities. However, some of the participants used the chat room with more frequency and self-reflection than others. Based on responses in the chat room and via email communication, community was built among participants and their self-efficacy was enhanced.

In the next chapter, Bartlett and Thompson provide the results of a qualitative longitudinal research study that followed 30 science and mathematics teachers across five cohorts from their preparation program into the early career years to better understand the conditions of professional retention and attrition. Findings indicate that the teachers exhibited little agency or discernment in the job search process and typically accepted the first position offered with little to no information about the school, students, colleagues, or teaching assignment. This decision has profound consequences for teacher turnover. Retention differences exist between teachers who choose their schools with robust information and those with very limited information. Furthermore, how and why teachers choose schools have profound consequences for their professional success and their persistence in high-need schools. This research study contends that professional retention of mathematics and science teachers in high-need schools starts with teacher articulation of workplace priorities and is coupled with a rich information hiring process.

In the final chapter of the volume, Ellis shares findings from the Teacher Induction Network (TIN), a Noyce-sponsored online induction program that has operated continuously at the University of Minnesota for over 10 years and has supported over 200 beginning STEM teachers. Through a design-based research approach and a commitment to continual improvement, TIN has leveraged emerging technologies and innovative mentoring practices to provide support to science teachers across the nation who are in their first few years of classroom teaching. This chapter shares quantitative and qualitative research findings that describe participating teachers' classroom experiences, evaluate the efficacy of mentoring supports provided through TIN for reformed STEM instruction, and highlight opportunities for future improvement and growth of not only the TIN program, but of STEM induction programs across the nation.

In summary, this edited volume fills a void in the literature on the recruitment, preparation, and retention of STEM teachers in a global society. In terms of recruitment, it is imperative to build trust and community to attract and support teacher candidates from underrepresented backgrounds (see Chapters 1, 3, 10, & 12). Additionally, it is important to support beginning teachers through chat room networks (see Burrows, this volume) and job searches (see Chapter 14) to reduce attrition. Teachers should be prepared to teach our most vulnerable children, while respecting their cultures and exhibiting an ethic of care that engages students in high-quality science and mathematics instruction (see Chapters 2, 4, 5, 6 & 7). While content is important in mathematics and science education, equitable instruction offers vulnerable students opportunities to learn and engage in STEM activities that have the power to improve the quality and substance of their lives by providing them with access to higher education and meaningful work that can allow them to give back to their communities (see Chapters 3, 8, & 10). Such opportunities begin with reforming teacher education (see Chapters 9 & 11) and transforming teachers to serve a higher sense of purpose for the public good. The chapters and recommendations in this volume add to the extant literature on STEM teacher recruitment, preparation, and retention in a global context by addressing the needs of K–12 students, preservice teachers, and teacher educators through transformative pedagogies.

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Figures and Tables

Figures

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