

A Teacher Preparation Framework Built on Research Insight

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Abstract

A typical pathway to become a credentialed mathematics teacher in a high school constitutes primarily of three parts; a bachelor's degree, subject matter competency, and the requisite professional education - courses and directed teaching. These are often delivered in a disconnected fashion with little attention given to the context. As research in teachers' knowledge indicates, placed in the context of high school, teachers often display surface knowledge and little confidence to present and defend mathematical concepts. The challenges posed by high-need schools only add to this problem leading to teacher attrition. In this article we propose and elaborate on a teacher preparation framework built on research in teaching and learning (The three Rs framework) that addresses some of these issues. In addition, we offer appropriate training modules along with their research underpinnings.

Keywords: *Initiatives in mathematics teacher training; Teacher preparation; Secondary teaching*

Introduction

Rigorous content background is albeit the initial point, the pivotal foundation in a mathematics major's journey as a teacher. However, to be able to face the content in context of a high school and the challenges of a high-need school, the institutes of higher education must equip their graduates with skills beyond **rigor**. They should also equip the future teachers with the foresight of the context by establishing the **relevance**, and insight of the workplace and their students by gradual familiarization – in turn boosting **retention**. In this article we propose *The three Rs* framework, which is built on insight from research as well as our professional experience as teacher educators. The first two axes of this framework are *rigor* and *relevance*. They stem from 1) agreements reached at the mathematicians-mathematics educators' debate about how best to teach mathematics in our classroom (Ball et. Al., 2005), and from 2) the MET report on preparation of teachers of mathematics (Conference Board of the Mathematical Sciences, [CBMS], 2001). The framework for success in high-need schools offered by Learning First Alliance (LFA, 2005) spawns our third axis of *retention*. Additionally, we provide some training modules to incorporate the latter two axes of relevance and retention into the existing axis of rigor.

The goal is to build prepared and competent teachers who are 1) knowledgeable in the **content** (mathematics), 2) capable to deploy the content in **context** (high-school), and 3) resilient in the face of **challenges** that a high-need school can offer.

Background: The Teacher Pathways

The pathway to become a credentialed teacher in a high school consists of primarily three parts: a bachelor’s degree, subject matter competency, and the requisite professional education courses and directed teaching. Enrolled full-time in a quarter-based system, a student will typically complete the sequence in 5.5 years, excluding summers.

We now describe the pathways to become a teacher in some details and how we can incorporate the training strategies of *The three Rs* framework using the platform of a large urban public university where the author currently teaches. Note that even though we show how the framework can be applied to a particular type of university, the idea is appropriate for any teacher training system that builds on subject matter competency and teacher education components.

The Traditional and the Alternative Pathways to Become a Teacher. In order to be a candidate for a teaching credential one must possess a bachelor’s degree and demonstrate subject matter competency. The teaching options in the mathematics program at this university are aligned with state standards for secondary teacher preparation programs and are approved by the California Commission of Teacher Credentialing ([CCTC], 2004). The collection of courses required for the teaching option is also known as the *subject matter waiver program*. It comprises of a considerably large collection of CCTC approved courses satisfying California breadth requirement for mathematics teachers.

Table 1

Examples of some of the paths taken by candidates to obtain a Single Subject Credential in Math

	Bachelor's degree	Subject Matter Competency	Professional Education Requirements
Traditional Path1	Complete BA (Math) with teaching option		Credential Program Or Intern Program
Traditional Path2	Complete BS (Math) with teaching option		
Blended Path	Complete BA (Math) with teaching option and Credential		
Alternative Path 1	BA or BS (math) (Non-teaching option)	Complete subject matter waiver courses or pass CSET	Credential Program Or Intern Program
Alternative Path 2	BA or BS (Non-Math Majors)	Complete subject matter waiver program or pass CSET	

The Blended Pathway. The blended pathway of the Mathematics degree program combines mathematics content courses and professional education courses through concurrent coursework. This new curriculum was designed by the author with goals to prepare credentialed teachers within 4 years of coursework, thereby expediting the teacher preparation pathway. This curriculum (200 quarter units) is considerably more concise than other existing blended programs (typically between 205-230 units) while keeping all the rigors of a general mathematics degree program.

Taking a cue from international degree programs and led by the urgency of staffing high-school classrooms of California, this comparatively shorter but subject matter wise equally rigorous path was achieved by carefully optimizing the number of general education courses

taken. This program was implemented in 2009 and promises to be an exciting opportunity for students who are dedicated to be teachers, and create a cohort as well as a focused support network.

The Framework of *The three Rs*. Typically a prospective teacher waits until his or her student teaching to address mathematics in the context of high school and the upcoming vocation of teaching. This is a divide admonished by numerous agencies and committees working to alter the STEM teacher shortage, such as California Council on Science and Technology, ([CCST], 2005). As Bruce Alberts, the President of the National Academy of Sciences points out in the National Research Council report on teacher assessment and quality ([NRC], 2001):

“Responsibility for teacher education in science, mathematics and technology can no longer be delegated only to schools of education and school districts; all faculty who teach undergraduates in these areas need to think about how their courses can contribute to the scientific and mathematical literacy of teachers (p. 11).”

Therefore, the prelude to induction in the teaching profession must be set in motion within the content department.

Consider our goal. We are aspiring to send our mathematics majors into high-need schools where they will teach pre-algebra, geometry, algebra, pre-calculus and possibly calculus. As a graduate of a mathematics degree program they are expected to be proficient in all of these areas and more. However, as research in teachers’ knowledge indicates, they often depart with possession of surface knowledge (see for example, Even, 1993; Simon & Blume, 1994; Zazkis & Campbell, 1996) and little confidence to present and defend mathematical concepts (Borko et. Al., 1992; Eisenhart et. Al., 1993). Prominent researchers, such as Liping Ma (1999) warn that without a profound understanding of the fundamental mathematical concepts placed in the context of teaching, there is little chance of a meaningful transition. And thereby even less chance of retention.

We argue that rigorous content background is the initial point, the pivotal foundation in the mathematics major’s journey as a teacher. However, it is but one dimension, and by itself cannot hold the structure together (Figure 1).

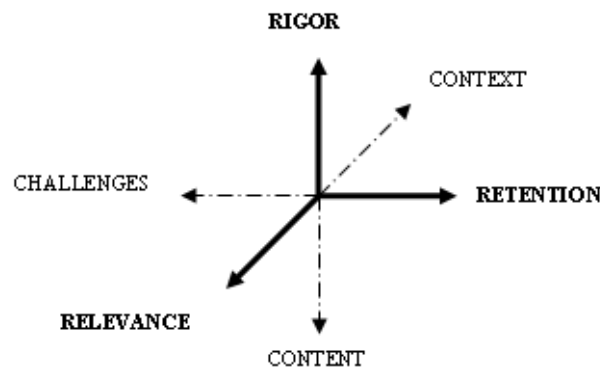


Figure 1
A framework proposed on research insight

To be able to face the content in context and the challenges of a high-need school we must equip our graduates with skills beyond rigor; the foresight of the context by establishing the relevance, and insight of workplace and their students by gradual familiarization. This research-informed pathway of the framework of *The three Rs* embedded in the expedited blended degree can not only attend to the problem of shortage of well-prepared teachers and related attrition, but has the promise to boost participation of disadvantaged and underrepresented populations in higher education over time.

We strongly advocate building the framework early in a teacher's career such as the first or the second year and reinforcing it in the third and the fourth year. Indeed we are currently working on such a proposal. However, presently we only offer modules which we are testing.

Incorporation Into the Curriculum

Toward this end we share the following training modules along with their research underpinnings; the first two focusing on the challenges of high-need school (workplace and student minds) with the second two addressing the content in context.

Module I. Facing the challenges: Human mind and Mathematics. Mathematicians and mathematics educators alike agree that while content knowledge is necessary to be a competent teacher, it is by no means sufficient as the following excerpt from the Mathematical Association of America document "Reaching for Common Ground" (MAA, 2005) suggests below.

"Teaching demands knowing appropriate representations for a particular mathematical idea, deploying these with precision, and bridging between teachers' and students' understanding. It requires judgment about how to reduce mathematical complexity and manage precision in ways that make the mathematics accessible to students while preserving its integrity (p.4)."

While the credential coursework provides an array of topics ranging from "The Teaching Profession" to "Special Instructional Methods in Secondary Subjects", none focuses on difficulties a human mind faces in order to comprehend the complexities of mathematics (for discussion see Artigue, 1992; Hazzan, 1999; Raychaudhuri, 2004).

Module IA. In this module, students taking the math methods course are introduced to cognition theories in mathematics, structure of mathematical entities, and analysis of samples of misconceptions arising from high-school students' works.

Module IB. Following this course, taken in year 3 of the degree program, the students participate in the service learning (while enrolled in the service learning course) in a high-need school and complete an observation report analyzing the patterns of learning observed – in the form of a journal and/or short video.

Module II. Facing the Challenges: High-need School, Knowledge, Understanding and Survival. Although most of our students are themselves graduates of a high-need school, experiencing the same as a teacher requires a different set of skills. *Professional Support* and *Preparation* form two integral pieces of the framework suggested by the *Learning First Alliance* in the document (LFA, 2005) addressing issues concerning staffing high-need schools. The

purpose of this document is to offer a framework that guides the efforts of LFA organizations and their affiliates as they work together to ensure all students have access to highly effective educators. The two pieces of the 8-piece framework-puzzle suggests to “Provide intense teacher support so that teachers succeed in challenging classrooms”, and to “Ensure that teachers and leaders are prepared to be effective in high-poverty, low-performing schools”.

Module IIA. The first part of this module is a workshop led by experts and veterans to discuss strategies to be successful in a high-need school, early in the year 3 of the degree program, followed by a day spent at a high-need school paired with a teacher mentor.

Module IIB. The second part of this module takes place early in year 4, *after* the students have participated in their service learning in a high-need school (see table 2 below). The students become the presenters in this follow-up day long structured workshop, offering insight for challenges and strategies alike from their own observation (documented in form of journal, and/or video) of teachers and students in high-need schools.

Module III. Content in Context: Advanced Mathematics in context of High School. One of the main ideas of the *Mathematics Education of the Teachers* Report (CBMS, 2001) jointly produced by MAA and AMS is that teachers need a deep knowledge of the mathematics that they teach. This knowledge, however, is different than the mathematical knowledge needed by other students.

“Prospective teachers need to understand the fundamental principles that underlie school mathematics ...College courses developing this knowledge should make connections between the mathematics being studied and mathematics prospective teachers will teach...Prospective teachers need to develop a thorough mastery of the mathematics in several grades beyond that which they expect to teach, as well as of the mathematics in earlier grades (p. 7).”

Through an NSF grant - Preparing Mathematicians to Educate teachers, (PMET, 2004) awarded in 2004, the author has designed and currently teaches a course in the above ideology that enables the mathematics major to make an effective transition from world of mathematical theory into the secondary mathematics classroom. This course builds on school mathematics, such as, algebra, trigonometry, geometry, calculus, proof and their links with advanced mathematics; particularly focusing on multiple representations and inter-connections between these topics. Each concept is pursued from three angles, 1) historical evolution of the concept, 2) multiple representations of the concept and 3) problem analysis, its connections with other concepts at horizontal and vertical levels. The activities include; analysis of research papers in cognition theories in advanced math, in class problem analysis sessions, pedagogical content knowledge sessions and assignment, exploring connections of advanced mathematical topics to high-school mathematics and a written final project connecting all four themes above. We discuss two of these tasks below. During the problem Analysis sessions students in groups discuss, analyze, solve and present to class the given set of problems (in increasing degrees of difficulty) connecting high-school math to advanced math. During reverse Problem analysis sessions, students in groups create set of problems connecting high-school math to advanced math. Then they critique and judge set of problems connecting high-school math to advanced

math designed by the other groups. In the final paper, students introduce a concept from advanced mathematics, followed by its multiple representations, historical evolution, a real-life problem analysis from various angles, making connections to the selected concept with other concepts-horizontally and vertically, creating a concept map, offering possible student misconceptions and remedies, and finally linking their work to existing educational research.

A capstone course such as this can prove to be extremely beneficial to the prospective teachers by making unknown connections of advanced mathematics they learn as math majors to the high-school level math they will be teaching, explicit, in turn deepening their mathematical knowledge.

Module IV. Content in Context: Infusing technology. Graphing calculators are powerful tools in mathematical study and problem solving with functions, including algebra and calculus. With the advent of new user-friendly features the use of calculators in pre-calculus mathematics and calculus has indeed become very common in high school and collegiate mathematics courses. Our module IV is a one-day calculator workshop in the year 4 of the degree program. Activities in this one-day workshop explore the variety of possible uses of calculators in analysis –from numerical and graphic exploration and problem solving to formal symbolic operations in algebra, calculus, and linear algebra, and carefully consider the interplay of technology and formal reasoning methods.

Table 2

A sample sequence in last two years of a Blended Program infused with the four modules shown in bold.

Fall			Winter		Spring	
<i>Courses</i>	<i>Units</i>		<i>Courses</i>	<i>Units</i>	<i>Courses</i>	<i>Units</i>
UD Mathematics course	4		UD Mathematics courses	8	UD Mathematics courses	8
Education courses	8		Education Courses	6	Education Courses	8
High-need Workshop MODULE IIA			Education Math Methods course MODULE IA	4	Mathematics Service Learning course MODULE IB	2
Fall			Winter		Spring	
<i>Courses</i>	<i>Units</i>		<i>Courses</i>	<i>Units</i>	<i>Courses</i>	<i>Units</i>
UD Mathematics courses	8		UD Mathematics courses	8	Education Course (Directed teaching)	14
Education Courses	8		Education Courses	8	Mathematics capstone course MODULE III	4
High-need Workshop MODULE IIB			Calculator workshop MODULE IV			

Conclusion

In this article we have proposed *The three R's* framework that strives to achieve the three-fold goals of *rigor*, *relevance*, and retention for secondary mathematics teachers in high-need schools. Integration of research, education and a need to serve the disadvantaged student population has formed the backbone of this framework. In addition, we have suggested four modules embedded in an expedited blended pathway to prepare the teachers through a rigorous mathematics content infused with insights from cognitive theories, in-context mathematics, and strategies to survive in a high-need school.

A comprehensive study done on California Community College system, the largest post-secondary education system in the world showed some startling results. The researchers Sengupta and Jepsen (2006) found that 75% of community college students focused on transfer courses in their first year never transferred to a bachelor's degree, even when they showed the same course-taking pattern of other successful students. A majority of those students came from Latino and Black population, in other words, the disadvantaged groups.

Note that a high percentage of California State University students are transfer students from California Community College system and originate from disadvantaged groups. Our goal to prepare these students as secondary mathematics teachers in the framework of *The three Rs* aligned with an expedited blended degree, not only attend to the present problem of mathematics teacher shortage in high-need schools, but in turn boost participation of disadvantaged and underrepresented populations in higher education. This framework has promise to modify teacher preparation by seeking to change societal norms – without which, researchers warn, no real change can happen in the arena of mathematical education of our children (Stedman, 1997). We are optimistic that this article will encourage discussions about the current state of teacher education programs that are predominantly divided into a set of Mathematics courses followed by a set of education courses and hopefully usher similar changes in teacher preparation programs at other universities, nationally and internationally.

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