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# PREPARING LEADERS FOR MATH AND SCIENCE: THREE ALTERNATIVES TO TRADITIONAL PREPARATION

*Improving student achievement in math and science has become a priority in the United States. As instructional leaders, principals can influence instruction in these vital subjects by working with classroom teachers to improve their instruction. Surprisingly, the research about the principal's role in supporting instruction in these subjects is limited, as is research related to principal preparation for content-specific instructional leadership. In this article, we draw from existing research to present three programmatic alternatives to existing preparation programs. These alternatives aim to strengthen preparation for content-specific instructional leadership in math and science.*

Improving student achievement in math and science has become one of the United States' top education priorities. There is growing concern among many groups that the United States is trailing its international peers in the competition to prepare the next generation of scientists, engineers, and mathematicians—fields considered essential for future economic success (National Academies, 2007). Considerable attention has been directed toward improving student achievement in math and science in elementary, middle, and high schools. Analyses of student achievement in math and science reveals persistent achievement gaps between students from racial/ethnic minorities and their Caucasian peers (Museus, Palmer, Davis, & Maramba, 2011). Further, there is ample evidence that these achievement gaps often persist throughout students' education and long into their professional careers if not addressed in their K–12 educational experience (Museus et al., 2011). Although many factors potentially explain the differences in math and science achievement, a significant portion of the variation may be attributed to differences in the quality of math and science instruction provided to students by their classroom teachers (Cohen, Raudenbush, & Ball, 2003; Kane & Staiger, 2008). Researchers believe that teacher quality varies dramatically from school-to-school and that historically disadvantaged student populations are often taught by less qualified teachers, particularly in math and sciences (Darling-Hammond, 2004; Flores, 2007; Gándara, Rumberger, Maxwell-Jolly, & Callahan, 2003; Peske & Haycock, 2006). As instructional leaders, principals have an important role to play in improving instruction in math and science by working with classroom teachers. Surprisingly, the research literature has not paid much attention to the principal's role in supporting instruction in these subjects, nor provided potentially effective strategies that may be effective to prepare principals for this type of leadership. In fact, our review

of the existing literature suggests that instructional leadership has been treated as a generic set of leadership actions that lack specific reference to the subjects that it seeks to influence.

The connection between a principal's instructional leadership and improved student learning is well-established in the research literature. Many researchers posit that improved instructional leadership is an important element in any school improvement effort (Copland & Knapp, 2006). Principals influence student learning by shaping the conditions in schools, structuring the instructional program, ensuring accountability among students and teachers, and supporting teachers' work (Blase & Blase, 2003; Grissom & Loeb, 2011; Supovitz, Sirinides, & May, 2010). At the classroom level, principals influence student achievement by working with classroom teachers to refine their instructional practice, and providing resources to support professional growth (Blase & Blase, 2003; Supovitz, Sirinides, & May, 2010). Analyses demonstrate that when principals engage in this leadership, it positively influences student learning (Edmonds, 1979; Hallinger & Heck, 1996; Leithwood & Jantzi, 1990; Leithwood & Louis, 2012; Louis, Leithwood, Wahlstrom, & Anderson, 2010). Surprisingly, educational leadership researchers have not spent considerable time discussing principal leadership related to specific content areas or their work with classroom teachers in specific subjects. We found that discussion related to the preparation of principals for leadership in specific subjects has received virtually no discussion despite analyses showing significant weaknesses in preparation programs (Darling-Hammond, Meyerson, LaPointe, & Orr, 2010; Davis, Darling-Hammond, LaPointe, & Meyerson, 2005; Hart & Pounder, 1999; Levine, 2005; Murphy, 1999).

In this article, we argue that one of the keys to improving math and science performance in the nation's schools involves developing principals who understand how school conditions influence efforts to improve math and science instruction that increase student achievement. As such, improvements in principal preparation activities are needed so that principals have a basic understanding of instruction as it relates to specific content areas. The purpose of this article is to discuss existing research related to principal preparation to identify the current weaknesses in preparation activities, and to propose three alternatives to existing preparation programs. If implemented, we believe these program designs would begin to strengthen preparation activities that will prepare principals to lead improvements in math and science. Furthermore, the alternatives attend to some of the perceived weaknesses in preparation programs cited in the educational leadership literature. We begin with literature summarizing the current challenges related to math and science in the United States. Next, we present literature related to the importance of principal instructional leadership as well as the current research on effective preparation activities. We conclude by discussing the three alternatives to existing preparation program designs beginning with the alternative having the most con-

servative changes and concluding with the alternative that makes the most dramatic changes. Our discussion ends with a review of the implications these alternatives have for preparation programs, as well as future research on effective leadership preparation strategies.

## Relevant Literature

In preparing this article, we reviewed literature broadly related to student achievement in math and science, research about principals' instructional leadership, and existing discussions of the strengths and weaknesses of principal preparation. We found within this literature three inter-related concerns. First, substantial research suggests that students in the United States are not performing as well in math or science as their global peers, and that much of this can be attributed to the teaching and learning conditions in the nation's schools. However, the discussion has not focused on the role that principals may have in improving student achievement in these important subjects. Second, as instructional leaders, principals can exercise considerable influence over these conditions, and research suggests that there is a relationship between instructional leadership and improved student learning. Yet, scholars have generally not focused on leadership actions specifically related to content areas. Finally, despite the importance of instructional leadership as a focus for principals, the literature on principal preparation suggests that many preparation programs do not adequately prepare principals to lead improvements in teaching and learning, And, of particular relevance to this discussion, there is hardly any discussion related to preparing principals related to leadership in content areas, such as math and science. We discuss each of these issues in the sections that follow.

### The Math and Science Challenge in Public Education

National concern about the need to improve math and science instruction is not new. In fact, it has been an issue of national importance since the 1950's. There is increasing evidence, however, that for all of the rhetoric related to math and science in the United States, the rhetoric alone is still not providing students with adequate instruction in math or science. The National Assessment of Education Progress (NAEP) indicates that for most of the past decade, student achievement in math and science has not increased substantially. According to the National Center for Education Statistics (NCES, 2011) significant disparities exist in math performance on the Scholastic Aptitude Test (SAT) between students of different ethnic/racial groups. Similarly, student SAT Math scores have not improved dramatically across ethnic groups over the past two decades (1990–91 to 2008–09). Furthermore, data obtained from post-secondary education reveals that metrics such as degree completion, participation

in STEM fields, and the career trajectories of graduates from the nation's universities reveal that many students—particularly students of color—are not pursuing education related to these fields (Museus et al., 2011). Researchers have linked these outcomes to the quality of math and science education students receive in the nation's K–12 schools.

Student performance in math and science in post-secondary education is heavily influenced by their high school preparation. For example, Adelman (2006) drew from data collected as part of the National Education Longitudinal Study (NELS: 88/100) to assess which factors predicted whether a student completed a post-secondary degree. He discovered that the content—which he referred to as academic intensity—of the student's high school curriculum predicted a student's completing a post-secondary education more than any other factor. Related to the intensity of the high school curriculum, researchers have also found that students perform differently depending on the academic track to which the school assigns them. Gamoran, Porter, Smithson, and White (1997) used a three-level hierarchical model of student scores in four urban school districts and found that students in more rigorous math courses outperformed their peers in less rigorous courses. Closely related to this, researchers have also shown that minority students often attend high schools with less access to Advanced Placement courses in math or science and, even when they do have access to these courses, they often participate in these courses in much lower numbers (Clewell, Anderson, & Thorpe, 1992; Ladson-Billings, 1997; Lewis, 2003).

Other school-level factors have been shown to predict student success in post-secondary math and science education, particularly among racial and ethnic minorities. Adelman (2006) studied high school curricula and found significant differences in the learning opportunities provided to low-income students compared with their more affluent peers. The National Science Foundation (NSF) (2010) reported that racial and ethnic minority students have less access to qualified math and science teachers. This claim is widely supported in education research which consistently shows that poor and minority students are often taught by teachers with fewer years of teaching experience or training that is not related to their content area (Darling-Hammond, 2000; Flores, 2007). Even if classroom teachers are qualified, many teachers maintain lower academic expectations for poor and minority students (Flores, 2007; Oakes, 1990). Each of these claims reinforces the view that disparities in education resources contribute to significant differences in student attainment in post-secondary education, as related to science, technology, engineering, or math and particularly in schools which predominately serve the largest proportion of low-income and minority students (Adelman, 2006; Flores, 2007; Oakes, 1990).

## The Importance of Instructional Leadership and Content-Specific Preparation

In the literature, we found many of the factors shown to affect student achievement in math and science fall under the principal's influence as an instructional leader. Indeed, the importance of educational leadership, especially principal leadership, has gained considerable attention in the education literature. Since the effective schools research identified principal leadership actions related to instruction as essential school improvement (e.g., Edmonds, 1979), researchers have sought to identify leadership actions that support instructional improvement and thus boost student achievement. Instructional leadership has been conceptualized in various ways (e.g., Blase & Blase, 2003; Murphy, 1988; Southworth, 2002). However, as Darling-Hammond et al. (2010) summarized, instructional leadership generally involves: working with classroom teachers to improve instruction; providing resources and professional development aimed at improvements in instructional capacity; coordination of curriculum, instruction, and assessment; regular monitoring of student and teacher performance; and cultivation of a school culture focused on improvements in teaching and learning. This conception has been widely advanced in the educational leadership literature (Knapp, Copland, & Talbert, 2003; Leithwood & Jantzi, 2000, 2005; Leithwood & Louis, 2012; Louis et al., 2010; Marks & Printy, 2003).

Strong principal leadership can address school conditions which research indicates typically disadvantage low-income and minority students in math and science. For example, as instructional leaders, principals can take an active role in this process by working with classroom teachers to provide opportunities for students to participate in these fields. Researchers have reported that students who are not native English speakers benefit from schools which offer strong, bilingual education programs that include courses in math and science (Gándara, 2006).Within the classroom, principals can support teachers in engaging students in these subjects by adopting culturally relevant or responsive teaching practices (Ladson-Billings, 1995; Lipman, 1995). Denson, Avery, and Schell (2010), for example, interviewed Black high school students to determine how their classroom instructional experience influenced their perception of math, science, and engineering. They found that teachers who introduced students to engineering as a career choice positively influenced the students' perceptions of the field. Students also benefit from early exposure to STEM fields. Researchers suggest these experiences change students' perceptions of these fields and prompt many students to participate in educational opportunities and careers related to these fields (Lewis, 2003; Oakes, 1990). In each of these cases, strong principal leadership was likely essential to introducing and sustaining these supports over time. Thus, as we assert in the next section, the need for a broader understanding of content-specific leadership and its implications for principal preparation is essential.

**Content-specific leadership preparation.** The alternatives that we propose in this article reflect a conception of educational leadership which emphasizes principal actions in support of improved math and science instruction. Unlike other concepts of instructional leadership which emphasize generic leadership actions—the conception we advance in this article focuses on leadership as it relates to a specific content area. As such, we argue that the conception emphasizes a set of inter-related leadership actions that, if taken together, could have a positive influence on math and science instruction in schools, and lead to improvements in both teaching and student learning. These actions have been shown in previous research to have a significant impact on instruction individually, and if taken collectively, could result in improved math and science instruction as well as improvements in other subjects.

Much has been written recently about focusing the attention and action of educational leaders on the improvement of student learning (Knapp, Copland, Honig, Plecki, & Portin, 2010; Knapp et al., 2003). Scholars have used various names to describe this form of leadership, among them learning-focused leadership (Knapp et al., 2010); leadership for learning (Knapp et al., 2003); and learning-centered leadership (Murphy, Elliott, Goldring, & Porter, 2006). The common element among these descriptions is that effective leaders place learning improvement—for students, professionals, and the organization as a whole—at the core of their work and use it to focus their leadership actions. This type of leadership requires a persistent and public focus on learning, sustained investments in the practice of instructional leadership, a reinvention or transformation in the work of instructional leadership, development of new, cross-organizational relationships, and reliance on evidence of growth and impact (Knapp et al., 2010). Leadership for math and science emerges from this conception in that the central focus for leadership action is to improve instruction, learning, and achievement in these content areas. To this end, we suggest that leadership for math and science has five characteristics:

First, leadership for math and science emphasizes the principal's role in supporting the dynamic relationship between pedagogy and content knowledge for the purpose of improving student learning. Effective instruction is not only dependent on the teacher's ability to assess how and whether their instruction is making content accessible to students but also on his or her understanding of the content upon which the instruction is based (Knapp & Associates, 1995; Reyes, Scribner, & Scribner, 1999; Schulman, 1987). Consequently, leadership for math and science not only involves asking the familiar questions about instructional practice but also seeking answers to questions which are less familiar to many instructional leaders. These questions include: What is adequate content knowledge? How do I assess it? How can a teacher's content knowledge be improved when it is deficient? Instructional leaders for math and science must have the capacity to help teachers identify and address gaps in teachers' understanding of the con-

tent they teach (Grant & Davenport, 2009; Howley, Larson, Andrianaivo, Rhodes, & Howley, 2007; Torff & Sessions, 2009; Zelkowski, 2011).

Second, leadership for math and science emphasizes the principal's role in encouraging the adoption and use of project-based or inquiry-based student learning. A critical task for education leaders committed to improvements in math and science is to foster a sense of exploration among students that is well-suited to math and science (van Zee, 2010). Furthermore, principals work with classroom teachers to make math and science content relevant to the world around them. The central question is not whether material is received, but whether they see the connections between what they are learning and the world around them (Boaler & Greeno, 2000; National Council of Teachers of Mathematics [NCTM], 2000; Rhodes, Stevens, & Hemmings, 2011; Zelkowski, 2011). This occurs when student learning is embedded in projects that have "a well-defined outcome, or deliverable, and a well-defined task" (Morgan, Barroso, & Huggins, 2009, p. 7), thereby creating an authentic learning opportunity for students. This kind of learning often happens in groups. Thus, students are able to use both their individual knowledge base as well as to leverage the knowledge base of other students in order to accomplish a unique task that provides new learning. However, creating these kinds of projects often requires resources, which necessitates a leader who understands how to (re)allocate or (re)invest resources in support of math and science instruction, including opportunities for collaboration as well as fiscal and human resources to prioritize. Additionally, for authentic instruction opportunities to occur, principals must create, encourage and support pedagogical risks in teachers' classrooms.

Third, leadership for math and science emphasizes teacher/leader collaboration within disciplines and across instructional domains to facilitate a shared focus or common understanding of the importance of achievement in these subjects. A variety of models exist to promote teacher/leader collaboration. The professional learning community (e.g., Stoll & Louis, 2007) is perhaps one of the most familiar. Professional learning communities allow teachers to have the structural, social, and human resources (Louis & Kruse, 1995) not only to collaborate, but also to co-construct (Louis, 1994) pedagogical practices through collectively meeting to make transparent or to "deprivatize" their practice, focus on student learning, and engage in reflective dialogue (Kruse, Louis, & Bryk, 1995) in order to increase student achievement. Through these processes, teachers can work toward shifting to, or increasing the use and rigor of, pedagogical practices that are inquiry-based, such as project-based learning (Capraro & Slough, 2009).

Fourth, leadership for math and science depends on leaders who understand how to invest or leverage resources to promote student achievement and educator development in math and science. Kelley (1999), for example, described how leaders leverage resources to support learning improvement, noting that leaders must often combine multiple funding streams and types of resources to support improved instructional delivery. In regard

to math and science, leaders must leverage human, monetary, programmatic, and partnership resources. This may require making strategic investments in professional development for classroom teachers, crafting master schedules that allow for inter-disciplinary collaboration that previously did not exist, or purchasing materials that help students learn independently using technology. Moreover, it may involve developing human resources through professional development, mentoring, or other capacity-building activities (Leithwood, 1994; Lord & Mahler, 1993; Plecki et al., 2009).

Finally, leadership for math and science involves developing partnerships to engage teachers, students, and the instructional program with the context surrounding the formal learning environment. Given the pace of changes in science and technology-driven fields, leaders will need to develop partnerships with industry, business, and academia in order to draw experts and expertise into their schools. Additionally, principals may engage external partners in order to help classroom teachers make learning opportunities relevant to students and the real world. With the increasing fiscal pressures placed on school districts throughout the United States, it is unlikely that any single school or school district can afford the accoutrements necessary to provide an instructional program that offers students and teachers the exposure they need for all the emerging applications for math and science. For example, principals might work with local businesses to create internship opportunities for students interested in engineering or the biomedical health sciences. A classroom teacher might draw from the more robust laboratory resources found at a nearby community college or university that his or her own school or district cannot afford to provide.

## Three Alternatives to Existing Programs

Building on this working conception of leadership for math and science, we propose three alternatives to existing principal preparation programs. If implemented, we believe these alternatives would fundamentally improve a principal's understanding of instruction in math and science as well as the actions they can take to support improved achievement in these subjects. Given the limited research on principal leadership in math and science, these alternatives represent our best thinking about what a preparation program more acutely focused on math and science might look like. For each of the alternatives we propose, we assume that the preparation program has certain characteristics in place. These characteristics have been cited in research on the most effective leadership preparation programs and are deemed essential to a robust preparation experience (Darling-Hammond et al., 2010; Davis et al., 2005). Each of our proposed alternatives assumes that the program structure is cohort-based, enrolls 20–24 students, spans approximately two years, incorporates a field-based internship, and admits students who are pursuing state-sponsored administrative certification. As illustrated by Table 1, the proposals we offer build from a traditional 30-credit

preparation program. Students begin the program in the summer and complete the program in approximately 24 months. Throughout the program, students complete activities aligned with key learning objectives and the Interstate School Leadership Licensure Consortium (ISLLC) standards. Consistent with research on effective internship experiences, the internship and academic coursework are closely aligned (Darling-Hammond et al., 2010).

**Table 1**

*Traditional Preparation Program*

| Term | Course | Credits |
|---|---|---|
| Summer | Leadership development seminar—emphasizes the personal and professional challenges facing school leaders. Discusses the relationship between leadership action and leadership values. | 3.0 |
| Fall | Instructional leadership—emphasizes the principal's role as a leader of learning. Provides particular emphasis on the micro-political relationships within the school, provides opportunities to practice observing and critiquing instruction. | 3.0 |
| | Internship—provides the intern with an opportunity to work toward the completion of a state-required 540 hour internship; students complete approximately 10 hours per week of activities. | 3.0 |
| Spring | Improvement of student learning—emphasizes the principal's role as a leader of learning, with particular emphasis on the use of data to improve student achievement and guide instruction. | 3.0 |
| | Internship—provides the intern with an opportunity to work toward the completion of a state-required 540 hour internship; students complete approximately 10 hours per week of activities. | 3.0 |
| Summer | Community and communications—a concluding seminar focused on the formation and leadership of a professional learning community, the stewardship of conversations related to social justice, and the centrality of parent/school/community partnerships. | 3.0 |
| Fall | Education law and accountability—provides an introduction to legal principles associated with school administration as well as a broad introduction to the influence that accountability systems have on teaching and learning. | 3.0 |
| | Internship—provides the intern with an opportunity to work toward the completion of a state-required 540 hour internship; students complete approximately 10 hours per week of activities. | 3.0 |
| Spring | Resource management seminar for school leaders—an integrated course introduces students to the principal's role as a leader of resources (people, money, time, and programs). | 3.0 |
| | Internship—provides the intern with an opportunity to work toward the completion of a state-required 540 hour internship; students complete approximately 10 hours per week of activities. | 3.0 |
| | Total Credits | 30.0 |

*Note.* For an illustrative discussion of the programmatic requirements for principal preparation, see http://education.wsu.edu/graduate/specializations/edleadership/#cert

In addition to the assumptions we make about the structure of the preparation program, we also assume that the design of the program, especially its curriculum, is embedded within a set of "design principles" (Bellamy & Portin, 2011). These design principles describe the cultural orientation of the program toward the development of leaders and the role of practice in that development. According to Bellamy and Portin (2011), who describe an innovative program they have designed based on these principles, preparation programs should be designed to link the preparatory experience with the core work of instructional improvement. As such, preparation is conceptualized as being about the development of a prospective principal's capacity to lead teaching and learning as well as to be an effective steward of school-based relationships. Related to this, the content of a preparation program should align with the district's improvement efforts and be equally grounded in theory and practice. To these four principles, we also note that effective preparation requires problem-based learning activities (Bridges, 1992; Copland, 2001). Bridges (1992) characterized problem-based learning as an instructional strategy that "organizes knowledge around administrative problems rather than disciplines" (p. 20).

With these assumptions guiding our discussion, we propose three alternatives to existing preparation programs: a traditional program with math and science content infused into the curriculum; a program that bases its delivery on the strength of an inter-disciplinary faculty; and a program that builds from each of these adaptations but introduces the concept of a leadership specialization in math or science. As illustrated in Table 2, the alternatives we propose offer different strengths and weaknesses. In the discussion that follows, we touch on each of these program alternatives and detail both the strengths and weaknesses of the various models.

**Table 2**

*Three Alternatives to Existing Preparation Programs*

| | Traditional Program with Math and Science Content Infused | Collaboratively Delivered Program with Inter-Disciplinary Faculty | Preparation as Leadership Specialists in Math or Science |
|---|---|---|---|
| Purpose | Strengthen leadership preparation by introducing math and science content. | Strengthen leadership preparation by leveraging faculty expertise and program content. | Strengthen leadership preparation by introducing a content specialization related to instructional leadership. |

*(continued)*

**Table 2** *(continued)*

| | Traditional Program with Math and Science Content Infused | Collaboratively Delivered Program with Inter-Disciplinary Faculty | Preparation as Leadership Specialists in Math or Science |
|---|---|---|---|
| Strengths | • Lower cost to implement<br>• Can be integrated without programmatic changes<br>• Increases coherence of preparation program curriculum | • Enhances the content expertise of faculty<br>• Requires modest changes to the preparation program curricula<br>• Increases coherence of preparation program curriculum | • Provides students with in-depth examination of a content area<br>• Offers an innovative model that could be used for other content areas<br>• Provides a clear connection to the internship |
| Weaknesses | • Limited improvements in application of theoretical concepts<br>• Faculty may or may not be familiar with the math/science content<br>• Does not address issues related to alignment with the internship | • May increase cost due to multiple faculty teaching courses<br>• Depends on faculty commitment to teach in an inter-disciplinary program | • Potentially narrows the scope of leadership preparation<br>• Requires modification to existing academic requirements<br>• Depends on faculty commitment to teach in a specialized program |

## Traditional Program with Math and Science Content Infused

The first alternative is the most conservative in that it merely adapts an existing program by introducing new content related to math and science. The alternative might be appealing to colleges and educational leadership programs, as it would be reasonably inexpensive to implement and would not require substantial modifications from external credentialing boards. In this alternative, we presume that courses on instructional leadership would continue to emphasize models or theories of principal instructional leadership. For example, the bulk of readings would still relate to general theories of instructional leadership (e.g., Blase & Blase, 2003; Nelson & Sassi, 2000). However, the instructor might choose to integrate Steven Leinwand's (2000) text, *Sensible Mathematics: A Guide for School Leaders,* to provide insights into leadership associated with improvements in math. Further, texts such as Sousa's (2007) *How the Brain Learns Mathematics* might be added to familiarize aspiring principals with the cognitive processes that occur when learning mathematical concepts. To enhance the instruction further, the faculty member might integrate other resources related to brain

development and mathematics (Ronis, 2006), leadership and its relation to student learning (Fink, Markholdt, Copland, & Bransford, 2011; Leithwood & Louis, 2012), and research related to differentiated instruction (Benjamin, 2002). The combination of these resources would strengthen the student's experience with to math and science content.

While this alternative represents an improvement over existing preparation programs, it does little to help aspiring principals develop leadership skills specifically related to instruction in math or science classrooms. This, we feel, is the core weakness of many preparation programs and is not addressed by this alternative. Additionally, the model maintains the survey approach to leadership preparation, which we believe does not adequately prepare principals for leadership in content areas. The survey approach emphasizes breadth at the expense of depth and misses opportunities to connect academic courses and the applied learning opportunities provided with the administrative internship. Thus, for this discussion and in the proposals which follow, we treat the concept of infusing math and science content into a preparation program as a starting point for any programmatic change. Each of the alternatives that follow includes new content specifically with math and science.

## Collaboratively Delivered Program with Inter-Disciplinary Faculty

The second alternative strengthens the delivery of the program by integrating faculty from across disciplines. Whereas the first proposal largely reflected a curricular change, this proposal combines curricular changes with changes in the program faculty. It reflects the assumption that many educational leadership faculty lack deep understanding of specific content areas and that the absence of this specialization can be addressed by incorporating other education colleagues. The alternative takes the stance that faculty from across a school or college of education should be engaged in developing future school leaders. In a program emphasizing leadership for math and science, for example, educational leadership faculty might serve as co-instructors with faculty who have expertise in math or science education. We envision the educational leadership faculty providing the expertise in leadership theories and perspectives while a colleague from teaching and learning provides expertise in pedagogy and content. Although we emphasize math and science as a focus, a similar approach might be used with language arts or literacy, bilingual education, or special education, depending on the needs of the school districts served by the program.

To illustrate how an inter-disciplinary approach might work, consider the example of an instructional leadership course. In many programs, an instructional leadership course serves as a theoretical introduction to the instructional improvement work of a school principal. Faculty provide the broad theoretical frames that researchers have empirically found to explain how successful principals engage in leader-

ship actions that improve instruction in their buildings. This introduction serves the conceptual needs of the program but does little to make explicit connections to leadership practice. In a collaboratively delivered program, an educational leadership faculty member might co-teach with a faculty member who has experience in math or science education. The combination would provide students with access to a strong theoretical expert and an instructional expert. The following scenario might be possible in a collaboratively-delivered program:

Faculty develop a course designed to prepare aspiring principals for the work of instructional leadership. The primary goal of the course is to introduce the student to both the theoretical and practical dimensions of principal leadership using math and science instruction as the point of reference. Throughout the course, the student receives instruction from both an educational leadership faculty member and a faculty from teaching and learning. The leadership faculty member sensitizes the student to the leadership challenges posed by inequitable student achievement in math and science. They also describe the generalized school improvement process. A central goal for the educational leadership faculty member is to contextualize the need for leadership action in the area of math and science as well as to consistently frame inadequate performance in math and science so that a student comes to understand how he or she could present the issue to his or her staff.

To this point, the course proceeds much as a traditional course would in that it has emphasized the conceptual ideas related to instructional leadership. However, after introducing students to the leadership challenges associated with improving math and science achievement, the faculty member from teaching and learning might begin connecting the discussion to the work of classroom teachers and provide opportunities for the students to practice instructional leadership behaviors with an individual who can emulate a teacher's response.

To complement the concepts presented by the leadership faculty, the teaching and learning faculty member provides students with an introduction to research on best practice in math and science. Lectures and presentations focus on questions such as "What is good math instruction? What does good instruction look like? How do you tell if students master the concept or idea?" As part of this effort, the faculty member shows students videotaped model lessons in math and science with the students and faculty then engaging in a debriefing about what they saw. In addition, the faculty members model for the students how they might conduct a conversation about improving practice with a struggling teacher. At times, the faculty member assumes the role of a classroom teacher and allows the students to practice offering feedback much as they would in a school.

While this change might not appear dramatic, the integration of faculty with different expertise reflects a significant departure from existing programs in that it provides significant opportunities to deeply engage students with the content. For example, the combination of faculty pro-

vides opportunities for students to practice leadership in new and innovative ways. Consider the following activity:

After learning about the connection between instructional leadership and math instruction, students participate in hands-on learning activities designed to introduce the concepts of project-based learning and to model how they—as principals—work with their staff to develop a shared understanding of what effective instruction in the content areas entails. The goal of these activities is to model how to design professional development to engage classroom teachers in considering how math or science instruction might be improved, as well as modelling the kind of hands-on learning activities that are effective when engaging students. To facilitate this experience, the faculty might, for example, provide students with supplies needed to experience project-based learning through constructing a small windmill. Their task is to design and build a windmill that would allow them to generate power for a community or lift an industrial load from a truck. After they demonstrate their windmills, the students and faculty engage in a dialogue about ways that they could make these activities relevant to different student groups and how they could, if needed, work with resistant teachers.

As illustrated, the scenario introduces certification students to the kind of hands-on learning that researchers indicate is essential for student success in math and science. It also simulates what a principal could do to engage staff in thinking about math or science instruction differently once assigned to a school. In this example, the students in the program reap the benefits of an experienced leadership scholar and an experienced teacher educator, as well as activities that are specifically tailored to content area. As a result, the connections between leadership theory and leadership practice are made explicit and the simulated professional development activity serves as an opportunity for modeling and reflection.

While this alternative improves existing preparation activities, it does present two significant challenges for educational leadership programs. First, the introduction of faculty from multiple disciplines who co-teach courses could result in increased cost to deliver the programs. While this may not pose a significant challenge to many colleges, those facing budget cuts due to declining state support for public universities may not be as amenable to this alternative. Further, as with any inter-disciplinary program, the success or failure of the program's delivery largely depends on the willingness of the faculty to work collaboratively to deliver the courses as well as to establish shared commitments about what should be covered within the context of the program.

## Preparation as Leadership Specialists

The final alternative we propose represents the most significant break with existing preparation program designs. The alternative introduces the concept of a content specialization for school leaders. Where-

as many preparation programs provide students with exposure to a wide range of topics and issues, the third alternative substantially narrows the focus of the program to prepare principals or teacher leaders with specific leadership skills. As such, it represents a significant break from preparing principals as generalists and replaces it with programs designed to prepare principals with a deeper understanding of instruction in specific areas. This alternative emerges from increasing interest on the part of the academic and philanthropic community in developing "turnaround principals," or principals who possess specific skills needed to improve student learning in specific areas. Further, it reflects the growing view that a tight connection between preparation programs and school districts is essential for shared programmatic success.

To achieve this specialization, the third alternative we propose infuses the program curricula with specific content and relies on an inter-disciplinary faculty. These are reforms that are essential to an improved focus on math and science content. The alternative also changes the program model by replacing general courses on instructional leadership with targeted content seminars aimed at developing principals' knowledge of instruction in specific domains. While an overarching conception of instructional leadership might guide the program, for example a program might use the concept of leadership for learning as a guide (Knapp, Copland, & Talbert, 2003); each seminar would help the students learn to apply their leadership within a content-specific context. In this discussion, we assume that content relates to math and science.

Much as in the previous alternative, principal certification students would complete a series of problem-based or performance-based tasks under the direction of an inter-disciplinary faculty. However, unlike the previous alternatives, the activities presented would be aligned with content areas. These would extend beyond the traditional activities such as formulating a school improvement plan, developing a communication strategy, or conducting a survey of school-level resources, to include activities specifically tailored to educational leadership for math and science instructional leadership. For example, a group of students might be presented with a scenario asking them to formulate a leadership response to declining student achievement in ninth grade algebra. The scenario might be presented in the following manner:

Assume you are the new principal at Merlot High School. Ninth grade students have consistently performed below the district average in Algebra, scoring between 20 and 25 points below their peers in the district. The achievement gap is widest between English and non-English speaking students. As the new principal, your task is to analyze the achievement data provided by the district's assessment office and develop an action plan to respond. The plan must include an analysis of the existing practices used to support math and science as well as a discussion of measures that will be used to monitor your school's progress over time.

The scenario provides students with an opportunity to work within a specific content area to acquire leadership skills that they could then employ in a real setting. Related to this activity, a student might be asked to plan and lead a professional development session focused on improving math achievement at his or her internship site. The purpose of both activities is to weave together theory and practice so that students acquire specialized skills in relation to a particular content area. Whereas the first and second alternative maintain many of the generalized concepts of school administration or principal leadership, the third alternative provides specific opportunities for students to link their leadership development with a content area.

## Implications

As much as the proposals we present offer opportunities to integrate math and science more tightly into a principal preparation program, they also provide a template for introducing other subjects into principal preparation programs. For example, using the same model, a preparation program could include special education, ELL or bilingual education, or even literacy, depending on the specific needs of the community and nearby school districts. We see this as one of the strengths of the proposal, as it opens opportunities for programs to introduce content that directly relates to the challenges facing school districts and supports the development of a collaborative relationship that researchers have deemed essential to the improvement of university-based preparation programs (Orr, King, & LaPointe, 2010). Further, the alternatives address one of the primary criticisms of preparation programs—that programs represent a combination of classes lacking a strong connection to the principal's role as an instructional leader (Hess & Kelly, 2007).

The models also provide possibilities for universities interested in providing certificated administrators the option to secure additional training or specialization in specific fields. This approach has been widely cited in research on teacher education, which calls for the establishment of a teacher preparation continuum in order to constantly expand a teacher's pedagogical content knowledge (Feiman-Nemser, 2001). Applied to content-specific leadership, principals could return to their preparation program to participate in professional learning activities related to specific content areas. For example, a principal might be initially trained in math and science. After a few years of service, the principal might return to acquire training in ESL or ELL instructional strategies. One of the strengths of this model is that it would establish a continuing connection between the administrator and the university, as well as provide the university with opportunities to generate fee-for-service professional development revenues.

Research on principal preparation programs indicates that the most effective programs often break from the traditional model that provides students with a series of disconnected classes. As Hale and Moorman (2003) not-

ed, the most effective programs are "cohort-based and serve 20-25 students who enter the program at the same time and are bonded into a community of learners" (p. 10). Moreover, these programs emphasize extensive application of theoretical constructs related to effective instructional leadership. In short, "students are given opportunities to solve real problems in real schools" (p. 10). In the third proposal we offer, the integrated program—including a field-based internship that takes place in the student's home school and nearby schools—seizes on this structure while linking it to specialized content. We see this link as critical to providing the kind of problem-based preparation which has been shown to consistently be a strong alternative to other methods (Bridges, 1992). This method allows principals to experience instructional leadership behaviors, to learn effective leadership skills, and to develop and articulate theories-of-action which support sustained school improvement.

## A Response to the Skeptics

The proposals we advance in this article, particularly the third proposal, represent a significant change to the focus of preparation programs. We anticipate that there are likely many who read these proposals with skepticism or reservation. We anticipate that many will argue that the content of preparation programs does not allow for an explicit focus on discipline-specific areas. Related to this, we anticipate that some will argue that being a principal requires a breadth of skills that makes content specialization unnecessary. Some may suggest that state regulations governing preparation programs make it impossible to change content without lengthy approval and review. Others may fear that formal cohort-based structures will lower program enrollment. Each of these concerns is legitimate and worthy of consideration. These alternatives are not meant as a panacea for programs but as a starting point for a thoughtful discussion about the relationship between leadership preparation and leadership for math and science.

What is also true is that there is ample research which suggests that school districts are inherently dissatisfied with many practices currently employed in university-based preparation programs and many states are responding to their dissatisfaction by allowing districts and programs with no affiliation to a university to prepare leaders (Orr et al., 2010). Surveys of superintendents indicate that they are not getting the kind of leaders that they need in order to improve student learning (Farkas, Johnson, & Duffett, 2003). Moreover, there are surveys of principals who say that their preparation did not pay sufficient attention to student learning or classroom instruction (Darling-Hammond et al., 2010). Indeed, as a high school principal in the state of Washington wrote on a recent survey about his or her preparation experience related to math and science, "I think administrators are somehow okay with the way math and science teachers teach because they may or may not know the content that well." Ultimately, we hope the alternatives presented serve as an invitation to join a dif-

ferent conversation about the scope and direction of preparation programs for school leaders that are possible. Most importantly, we see these alternatives as a call to be innovative and bold in making improvements to university-based preparation programs.

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