PROJECT SUMMARY REPORT

Rethinking Pre-College Math:

Pedagogy, Professional Responsibility, and Student Success

William S. Moore
Emily Lardner
Gillies Malnarich
Michael Davis
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Rethinking Pre-College Mathematics for Washington Colleges

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This report is one of three distinct but related reports focusing on the Re-Thinking Pre-College Math project. In addition to this overall project report, there is a study specifically addressing math faculty perspectives on the role and value of professional development in the project, based on a set of in-depth faculty interviews (Asera, 2013), and a formal evaluation report which will include more extensive evaluation findings and data analyses, including student survey data (to be published in March 2013).

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The Re-Thinking Pre-College Math (RPM) Project:

Pedagogy, Professional Responsibility, and Student Success

Executive Summary

Many factors contribute to the variety of significant problems in pre-college (developmental) mathematics in two-year colleges, and many reform efforts have been developed in an attempt to address them. A core premise of the RPM project is that student success in pre-college math is directly linked to students' experiences in math classes, and students who experience more engaging, relevant learning are more likely to succeed. The RPM approach was built on the assumption that changing ineffective curricular structures and improving student support are necessary but not sufficient solutions to improving student success in pre-college mathematics. The real lever of sustained long-term improvements in student success and learning in pre-college mathematics, especially the critical project goals of increasing student engagement in math and deepening students' mathematical understanding, is improving faculty practice, taking a faculty-driven and department-centered collective approach to answering these central questions:

- What math do we teach (and why)?
- How do we teach?
- How do we know students have learned the math?

The seven Washington colleges in RPM implemented structural solutions tailored to their specific local contexts while the overall project focused on building a common effort to address the issues of pedagogy and professional responsibility at the heart of these central questions. The RPM project guided the math departments involved in the project to use some designated common practices—**classroom assessments, classroom exchanges, and faculty inquiry groups**—to help faculty address these issues and their connections to student success. These common practices were intended to help build the capacity of individual teachers, groups of teachers, and ultimately departments, to think critically about the relationship between teaching practices and student learning, with the goal of changing teaching practices in ways that increase student learning. For RPM the college math department (and/or developmental math program) was the unit of change, not individual faculty.

While promoting college-specific structural reforms, RPM encouraged convergence through consistent structured protocols and ongoing technical assistance across the colleges. Over the course of the grant, the goal was to support the college faculty in sharing their work in ways that would help faculty learn from each other and that would encourage the spread of innovations, both within the individual colleges and across the colleges participating in the project. To the extent that the RPM project reflected a single "reform" model it would be characterized as developing a critical mass of faculty in a pre-college math program or department who a) acknowledge what they are responsible for collectively in terms

of student achievement in pre-college math, and then b) through a range of shared practices and protocols design effective ways to address those responsibilities, both individually as faculty members and collectively as a department or program.

During the full implementation years of the grant (years two and three), approximately 80 percent of the college sub-grants were invested in supporting faculty engagement for both full-time and part-time faculty. In general the investments took the form of reassigned time or stipends for project leadership, curriculum design, and participation in core activities (faculty inquiry groups, classroom exchanges) as well as support for more traditional professional development activities (consultants, travel, etc.). In that time period, of the 250 or so math faculty (full-time and part-time) across the seven RPM core colleges roughly three-quarters were involved to varying degrees in some aspect of the common RPM work, with some 15 percent of them taking on leadership roles in the work at their colleges.

Critical "Lessons Learned" from the RPM Project

The following recommendations represent our considered reflections on how best to approach this kind of comprehensive re-thinking of pre-college math programs in community and technical colleges: what seemed to make the most difference in terms of supporting and sustaining faculty and math departments in their efforts to increase student engagement in math learning and deepen student understanding of key mathematical concepts?

- Address core beliefs and perspectives about math, students, and learning that shape instructional practice.
- Develop shared understandings (project goals, mathematical competency, student learning, etc.) and collective responsibilities for student success in math.
- Pursue collective inquiry through structured protocols and common practices around instruction and assessment with an emphasis on increasing student engagement and improving mathematical understanding.
- Acknowledge that the critical elements (content, instruction, assessment) of re-thinking pre-college math are interconnected and can't be addressed in isolation.
- Emphasize faculty making meaningful **but manageable** changes in the core areas of instructional practice related to classroom teaching and assessment.
- Develop and support teacher leaders in promoting and sustaining change initiatives in order to address issues of "scaling" innovations over time.
- Promote a culture of improvement and innovation, both within and across colleges, encouraging faculty to learn from, and share publicly, experiments in teaching and learning.

The evaluation evidence gathered to date, which will be published in full in a separate report (March 2013) and the companion faculty interview study (Asera, 2013) suggest strongly that the project has been successful in influencing faculty behaviors and perspectives so critical to achieving the longer-term project goals. The project has produced a number of emerging faculty leaders across the cohort of colleges, faculty committed to working with their colleagues around what they have learned through RPM and the departmental changes they have put into place. We believe those leaders can be the genesis of the math movement that is needed, and we are committed to finding ways to support them in their continuing efforts to shape their department and college cultures in ways that make a meaningful difference for student learning in mathematics.

Introduction:

RPM as a Faculty and Department-Driven Math Reform

> Currently there is great interest in reforming developmental mathematics education at the community college. Yet, it is worth noting that almost none of the reforms have focused on actually changing the teaching methods and routines that define the teaching and learning of mathematics in community colleges. Many schools have instituted courses that teach students how to study, how to organize their time, and how to have a more productive motivational stance towards academic pursuits… They have created forms of supplemental instruction…[and] tried to break down bureaucratic barriers that make it difficult for students to navigate the complex pathways through myriad courses that must be followed if students are ever to emerge from developmental math and pass a transfer-level course. Some have redesigned the curriculum - e.g., accelerated it, slowed it down, or tried to weed out unnecessary topics. Yet few have questioned the methods used to teach mathematics…**Substantive improvements in mathematics learning will not occur unless we can succeed in transforming the way mathematics is taught.** [emphasis added]
>
> (Stigler et al., 2010, p. 5)

- What math do we teach (and why)?
- How do we teach?
- How do we know students have learned the math?

These three questions reflect what Richard Elmore (1996) has called the "core of educational practice" and represent the central focus of the *Re-Thinking Pre-College Math* project (RPM), a 2009-2012 initiative led by the Washington State Board for Community and Technical Colleges and funded by the Bill & Melinda Gates Foundation.

Considered together, these questions highlight meaningful pre-college math reform as a deliberative faculty practice in which understanding students' experiences of learning in the classroom is paramount. The first question, "What math do we teach (and why)?" focuses on an examination of curricular content and structure in relation to desired learning outcomes. The second, "How do we teach?" invites a collective scrutiny of the effectiveness of current classroom instruction. And the third, "How do we know students have learned the math?" addresses the need for assessment strategies that are relevant to both student engagement and mathematical understanding. Faculty cannot address these questions successfully without some consideration of the relatively new and significant science of learning (Bransford, Brown & Cocking, 2000), including research on how students learn mathematics (Donovan and Bransford, 2005), and the inherited and often intimidating traditional practices and policies of math departments.

Posing these central questions served as a starting point for the Re-Thinking Pre-College Math project but they also define the distinctive nature of RPM's contributions to developmental math reform efforts: questions about core educational practice are questions posed to and by educators, the *teachers* of struggling math *learners*. If the answers are to result in more than isolated instances of change in a scattered collection of classrooms across a campus or state, a project design must identify what needs to be in place to bring to scale changes in curricular structures and college programs as well as faculty behaviors and beliefs, both within a college math department and across multiple colleges in a system. From its inception, the RPM project shared the common aim of other developmental math reform efforts—to accelerate student progress through long developmental math sequences and improve their success in college-level math—but RPM's distinctive approach has been to emphasize collective faculty- and department-driven math reform centered on transforming classroom practices.

In this respect, RPM builds on the successes and lessons learned from the Washington *Transition Math Project* (TMP) , a collaborative initiative focused on high schools and the transition to college which involved educators from K-12 schools, community and technical colleges, and baccalaureate institutions. Among its accomplishments—and supported by various statewide agencies and community stakeholders—TMP educators defined consistent and clear college readiness expectations in math so high school teachers could effectively prepare students to succeed after high school and avoid remediation math. TMP also set up local/regional partnerships to provide opportunities for high school and college instructors to share math curricula, teaching methods, and best practices. RPM continued this collaborative approach to math educational reform but with a primary focus on pre-college math programs in Washington community and technical colleges. (See Appendix A for more background details about the RPM project.)

Troubling data and the developmental education dilemma

Many faculty teaching developmental mathematics are not only increasingly aware of the data about the poor performance of students in math, they are also burdened by the implications for their own teaching practice. Nationally, almost 60 percent of community college students take at least one remedial (developmental) education course (Attewell, Lavin, Domina, & Levey, 2006). In Washington State, 57 percent of the roughly 20,000 students graduating from high school in 2010 and entering the community and technical college system enrolled in at least one pre-college course in 2010-11, with math the biggest draw at 51 percent, compared to only 19 percent in writing (SBCTC, 2012). Hispanics and African Americans were substantially more likely than all other students to be enrolled in these classes.

Unfortunately, as a growing number of studies, reports, and conference gatherings over the last few years have noted (e.g., Bailey, 2009; Complete College America, 2012; National Center for Postsecondary Research, 2010, 2012), while developmental education within community and technical colleges serves as a critical access point for many students into post-secondary education, its track record on students moving successfully from pre-college to college-level work is poor. Fewer than half of those students referred to developmental education complete the recommended pre-college courses, and fewer still enroll, let alone complete, the college-level courses they need to pursue their college and career plans. These data are particularly disturbing given the significant societal role that two-year colleges can and should play in terms of addressing equity and opportunity issues for students historically underserved by higher education. For many students, developmental coursework, especially math, has become a serious roadblock in their efforts to get the courses they need to achieve their life goals and career plans.

Despite the fact that issues and concerns about developmental education have become increasingly visible to educators, policymakers, and funders, proposed remedies

rarely highlight the centrality of the teaching and learning that occurs in the classroom. The specific reform strategies and solutions being tried or proposed are varied and significant, but the approaches most frequently used, especially in math, have focused on reducing the length of remedial programs by accelerating student progress (Hern, with Snell, 2010) to "gateway" college courses through new curricular structures (e.g., Virginia Community Colleges' modular approach, and new content "pathways" that are part of Carnegie's Statway and Quantway initiatives). These efforts address the first question—what math we choose to teach—in provocative and powerful ways; the other two questions regarding how we teach and how we assess learning are either treated as secondary or minimized.

The curricular reforms designed to accelerate student progress through developmental coursework were intended to increase the number of students who achieve degrees and credentials, but some (e.g., Deborah Humphreys, 2012) have suggested that the primary driver of the reforms is reducing cost, and that a focus on the quality and depth of the student learning is generally missing from both reform efforts and policy discussions; "acceleration" inherently involves a trade-off in favor of more immediate and often limited learning outcomes. In addition, while some of these developmental education initiatives acknowledge the need to address the professional learning of faculty in implementing significant reforms, relatively little attention has been paid to the development of faculty leaders, who are needed to introduce and sustain the departmental and institutional shifts required by such work.

Faculty responsibility for sustaining educational reform

While addressing the principles and structural changes currently framed as the "fix" for the challenges of pre-college math undoubtedly decreases some of the issues that students face, these curricular solutions do not reduce the substantial obstacles associated with other core areas of educational practice. The pedagogy currently in place is not effective for many of the students in these pre-college math programs; moreover, we know that changing the curriculum will not magically change the way teachers teach. In addition, we recognize the need to teach math concepts in ways that are meaningful to and engaging for students.

Focusing on these improvements requires significant improvements in faculty skills, and perhaps more importantly, in their fundamental understanding of their role and responsibility for student learning. And while it is the responsibility of individual faculty members to initiate these changes, successful and sustained reform requires a collective approach, with personal change processes occurring within the context of a departmental transformation that supports and reinforces the work of individual faculty.

In a much-repeated quote, H.L. Mencken once observed, "For every complex question there is an answer that is clear, simple and wrong." The interventions touted as answers to the complex problem of two-year college developmental mathematics are not "wrong" exactly, but they are decidedly incomplete, and do not allow for faculty to play a full and meaningful role in the process. In essence, the intent of the RPM project has been to keep math teachers at the center of pre-college math reform and support them in their collective efforts to address core areas of educational practice.

The three questions which served as the foundation for the RPM project were based on a simple premise confirmed by the extensive work over the years in the scholarship of teaching and learning (SoTL): every classroom of students poses a complex and messy array of challenges for faculty committed to student success. By continually asking what we teach, how we teach, and how we assess learning, committed faculty can discover potential solutions to those challenges. It is those questions and subsequent discoveries by individual faculty members that will lead to significant change in students' learning experiences, helping them make progress toward enrolling and succeeding in college-level math courses; in this way improvements in student learning are tied explicitly to more effective teaching. Supporting the asking of those questions—and bringing committed faculty together to establish an intentional professional learning community that could transform the culture of traditional math departments—were the clear and central emphases of the RPM project.

Focus of this report

This report provides a descriptive overview of RPM project-wide activities as well as a distillation of what we believe are the most significant "lessons learned" from the work. We begin

with an overview of the RPM project approach and reform model, and then turn our attention to the teaching challenges—specifically the relationship between students' experiences of learning and faculty practice in the classroom—and the over-arching project strategies developed to address these challenges of professional practice. A concluding section details a two-part set of recommendations based on the experience of the project. The first part is from faculty involved in the project on what they have learned about changing curricular content and structure, making significant but manageable changes in instructional practices, and improving assessment strategies to support engagement and understanding. The second part, developed by the project leadership, offers a meta-perspective on the RPM approach to the comprehensive and fundamental re-thinking needed to repair the broken "remedial bridge" (Complete College America, 2012) of pre-college math in community and technical colleges. These recommendations address the critical components involved in implementing a faculty- and department-driven math reform that recognizes the centrality of the faculty role in addressing classroom practice—the critical factor in any educational change initiative designed with students' experiences of learning in mind (Tinto, 2012).

RPM collected both quantitative and qualitative data project-wide on faculty efforts and student achievement as part of its project evaluation activities. The project-wide quantitative data drew on the Student Achievement Initiative (SAI), a statewide effort of the State Board for Community and Technical Colleges. These data, along with a description of the SAI approach and its strengths and limitations in the RPM context, can be found in Appendix C. A more thorough evaluation report focusing in more depth on the qualitative evaluation (faculty interviews, student surveys, site visits) conducted for the project and providing a core foundation for this report is forthcoming (Davis, 2013).

In addition to these project-wide efforts, RPM also built capacity for faculty to deal with data, to look critically at local data and to consider ways to use data to evaluate changes they made in their developmental course sequences. RPM encouraged and provided technical assistance for the project colleges to conduct their own local evaluation efforts, focusing on specific, and faculty-driven, questions tailored to their local interventions with students. The colleges have provided brief summaries of these activities, along with some examples of the data collected, in Appendix C.

A central component of the RPM theory of change is that making significant improvements in learning outcomes for developmental math students, including their progress to and through the college-level math courses they need to succeed in their academic programs, requires careful attention to intermediate outcomes related to faculty learning and changes in classroom and departmental practices. Achieving meaningful reforms that address these student outcomes requires a long-term commitment by math faculty and college math departments; the three-year RPM project focused on the critical elements involved in building a foundation for that ongoing commitment that can be sustained over time. This report describes those efforts and what we have learned in the process.

Overall Project Approach:

A Reform Model for Local Control States

In recent years, major national projects such as the Developmental Education Initiative (Collins, 2011) have supported a handful of states in addressing statewide policy levers aimed at improving developmental education. These approaches have to varying degrees involved faculty and focused on curricular efforts, but design and implementation have almost exclusively occurred in contexts where both the problems and the solutions were defined top-down within the educational system. This fact becomes particularly significant as we approach reform in Washington State, in which, as with a number of states across the country, the educational system operates with a more decentralized governance structure than those that participated in the Developmental Education Initiative. As David Altstadt (2012) noted:

High-level governance structures have implications for faculty engagement. “Decentralized” states, in which community colleges are governed and operated at the local level, lack clear authority to convene faculty across institutions, let alone set state-level policy. (p. 3)

For the community and technical college system in Washington State and for other similarly decentralized systems across the nation, there are particular challenges involved in pursuing at any scale the kind of faculty- and department-driven reform that the RPM project represents. Moreover, regardless of the governance structure, state-level policy has relatively little impact on what happens in higher education classrooms. Given the critical importance of making changes in classroom practice, the RPM approach and strategies for engaging departments and individual faculty can provide a critical model, especially for other local control states, for addressing those changes in the context of developmental mathematics reforms. Around these overall issues, the three major elements of the RPM approach were: **engaging the system** as a whole, **active shaping** and sharing of proposal ideas, and **ongoing communication** across the system.

Engaging the system

The RPM project was initiated with an open invitation to a system-wide convening of college teams prior to the application and selection process for participation in the RPM cohort. This initial gathering engaged teams from half the colleges in the system in a multi-day institute focused on clarifying issues and potential models for developmental math programs. These included the scholarly perspective of national experts as well as the framework proposed for the RPM project. College teams who potentially could serve as leadership groups on their individual campuses had the opportunity to exchange ideas about what was possible and explore the fit between their own issues and concerns and the focus of the project.

Active shaping of proposal ideas

Following the kick-off event, interested colleges were encouraged to arrange for campus visits from the project leadership group prior to the proposal submission deadline. During these visits the project leaders observed developmental math classes and met with key faculty and instructional administrators, both individually and in groups. The discussions focused on exploring what people saw as their most significant issues involving developmental math, helping determine to what extent there was any clarity and consensus around what should be addressed, and brainstorming strategies to address the identified concerns. Depending on where the college/department was in its own process, in some cases the project leaders offered specific feedback and advice regarding tentative proposal ideas and shared relevant approaches from other colleges within the system.

Ongoing communication with faculty and administrative leadership across whole system

After the cohort of colleges was formally selected and had begun their local implementation projects, the RPM project as a whole maintained a network of contacts among both math faculty and instructional leaders in all 34 campuses in the system, not just the seven formally included in the cohort. RPM kept this network informed of project activities and opportunities on a regular basis, including invitations to project retreats and institutes. As a result, several additional colleges were actively involved in project gatherings and even received small sub-grants to be involved in focused initiatives related to specific elements of the overall RPM project. Project leaders also provided periodic RPM updates at regular system meetings of math faculty, deans, and academic vice-presidents. Project activities and resources were also made available across the system through a public wiki site.

Rather than imposing a single defined solution, the RPM approach was to expose the colleges to a range of promising approaches from around the country and then allow the individual college math departments to determine the specific structural changes in pre-college math that had the best potential for success with their students given their specific context. The specific structural changes implemented by the colleges are described in some detail in Appendix B, along with contact information for the project leaders.
For the RPM project as a whole, these structural changes to the pre-college math curricula and programs are less important than the core principles and overall strategies for the project, to be described in the remainder of this report. The RPM approach provided a framework in which math faculty and college math departments across the system could develop their own curricular solution and at the same time come to see the need for greater convergence across the colleges in their efforts to improve developmental math programs.

What is particularly significant and powerful about this approach is that it models and parallels the research-based student learning principles and good instructional practices shared with faculty through the RPM project. Too often in change/reform efforts there is far too little acknowledgement that, especially when it comes to pedagogical issues, faculty are learners like students. For powerful learning to occur it is critical to a) understand what students know and don't know and "meet" them where they are; b) engage their sense-making about the subject matter at hand; c) make learning visible, shared, and public for all involved; and d) seek wherever possible to both empower and enable them as learners. The RPM project applied these same principles to supporting and leading faculty in our efforts to improve developmental math.

Teaching Challenges:

Clarifying the Relationship Between Students' Experiences of Learning and Faculty Practice in the Classroom

> **The intentions were noble. It was hoped that remediation programs would be an academic bridge from poor high school preparation to college readiness — a grand idea inspired by our commitment to expand access to all who seek a college degree. Sadly, remediation has become instead higher education's "Bridge to Nowhere." This broken remedial bridge is travelled by some 1.7 million beginning students each year, most of whom will not reach their destination — graduation. It is estimated that states and students spent more than $3 billion on remedial courses last year with very little student success to show for it. While more students must be adequately prepared for college, this current remediation system is broken. The very structure of remediation is engineered for failure.**
>
> **(Complete College America, 2012, p. 1)**

Digging deeper into the data noted earlier about the lack of student success in pre-college education, and math in particular, reveals troubling classroom practice, as evidenced in particular by research done by Policy Analysis for California Education (Grubb, Boner, Frankel, Parker, Patterson, Gabriner, Hope, Schiorring, Smith, Taylor, Walton & Wilson, 2011). The classroom observations we conducted in Washington State community and technical colleges reinforced those findings and shaped the approach taken in the RPM project. In contrast to the analysis offered by Complete College America, which identified ineffective curricular structures and lack of student support as the key causes of the break in the "remedial bridge," we found that the challenges in improving student success in precollege math derived from several deeper and less-often addressed issues of professional practice:

- Instructional approaches that don't meet the needs of many students in pre-college math classes
- Faculty who are unwilling or unable to acknowledge and take responsibility for their role in student learning
- Departmental cultures that neither encourage nor reward innovation, and when innovations do occur, they are too often isolated and idiosyncratic

Instructional approaches

Stigler and his colleagues argued that the way mathematics is taught is both central to the challenges in pre-college math and too often ignored. "Remedial pedagogy," a term Grubb et al. (2011) used to describe the typical lecture-and-drill instructional approach they saw in their observational study of developmental classrooms in California community colleges, is deeply ingrained in the culture and tradition of higher education, especially in developmental math. This approach can be functional for some students, particularly those who are adept at "schooling," but it tends not to engage students who have struggled significantly with the subject matter, as is the case with many learners in developmental math. These students generally have not been successful with this approach in their previous educational experiences, so it's not surprising that they struggle with it in a setting where the pace of content coverage is considerably faster than in high school.

Despite the considerable research that has deepened our understanding of student learning processes in mathematics (Donovan et al, 2005; Hodara, 2011; Stigler, Givvin & Thompson, 2010; Givvin, Stigler & Thompson, 2011), this work has had little impact on the actual classroom practices of higher education faculty. Shulman (2000) suggests why the lecture approach continues to dominate teaching in higher education:

> Teaching demands principles of both exposition and discussion…That complexity is the reason why, even though we know discussion is necessary,

the dominant form of pedagogy is the lecture. Lecture is relatively simple, and it reduces much of the technical and economic complexities of teaching. (p. 132-33)

Shulman also argues that without a more balanced incorporation of discussion and student engagement, teachers will continue to struggle with the problem of "illusory understanding," that is, students who on the surface appear to understand something but really do not, an issue that Stigler's research (2010) underscores as particularly widespread in mathematics. Shulman's (2000) solution is to "engage students in active thinking about what they know and how they know it and… create conditions where they can discuss what they know with others" (p. 131).

In conducting our own observations in Washington community and technical colleges, we confirmed the prevalence of the "remedial pedagogy" that Grubb describes in his work. We saw a few examples of classrooms where students were invited to engage in active thinking, but these classroom practices were not the norm in any department. Many faculty expressed frustration with what they experienced as competing demands: on the one hand, to "cover" material, and on the other, to teach in ways that ensured student understanding. Recognizing the power of faculty autonomy in the classroom, the RPM project, rather than preaching to faculty about the perils of the traditional lecture-dominated mode, opted instead to provide opportunities for departments and individual faculty to expand their repertoire of instructional approaches. The intent was to create a shared focus on difficult goals to argue with—i.e., increasing student engagement and mathematical understanding—and the need to explore, through collaborative inquiry rather than prescription, instructional strategies that can address those goals.

Faculty role and responsibility in student learning

Changes in instructional practice generally require changes in faculty perspectives about their appropriate role as teachers and their responsibility for student learning. At the most basic level, whether a faculty member views his or her role as providing information rather than promoting learning has profound implications for how much personal responsibility he or she takes for student success. Instructional approaches are difficult to change unless, at the same time, we can help faculty understand a) what they can do to improve student success and learning in math, and b) recognize both the extent of and the limits to their responsibilities for this learning.

In our conversations with faculty we observed a number of faculty already exploring innovation approaches in their classes and eager to learn ways they could be more successful with their students. At the same time these conversations helped us understand that there were many faculty who were generally reluctant to take more responsibility for student learning without having more tools or strategies that would enable them to be successful. Even when they wanted to change their practices in order to take more responsibility for student learning, faculty were not sure how to do so. They felt constrained in their choices in part due to lack of time and the push to cover courses in a sequence, and in part because they lacked access to research-based strategies that could be implemented incrementally. Consequently, RPM sought to engage faculty ownership of and responsibility for the reform work by re-framing the focus as a need to find ways for **engaging students** in "doing math" and to deepen students' **mathematical understanding.**

Departmental culture around innovation

The study by Grubb et al. (2011) found that virtually all colleges have faculty who, on their own, are revamping their developmental classes and pursuing innovative approaches to instruction in efforts to improve student learning and success, with little or no support from their department or institution. On the one hand, these individuals creating important changes represent the "upside" of faculty autonomy and academic freedom; it is inadequate, however, for addressing the overall need for reform at any meaningful scale:

> It's impossible to rely on this kind of idiosyncratic innovation as a way of improving instruction in basic skills: it is too individual, too isolated from the practice of other instructors, and too limited in scope to influence instruction for more than a small number of individuals. (Grubb et al., 2011, p. 14)

In his research, Grubb found that it was rare for institutions to move beyond these isolated innovations and sustain significant reforms in their developmental programs; the few that were successful in defining a clear alternative to remedial pedagogy shared some common elements:

- Acknowledging publicly that the status quo was not working for many students and taking collective responsibility for doing something about it
- Investing resources in the work over a significant period of time (at least ten years)
- Tackling directly specific aspects of the remedial pedagogy model
- Building constructive partnerships between faculty leaders and mid-level administrators (deans, division chairs, etc.)
- Addressing faculty hiring and mentoring processes to support new and seasoned faculty in changing practices

Our observations and campus visits revealed wide variation among math departments in the Washington State community and technical college system reflecting these significant elements. Consequently, RPM explicitly focused on the math department and/or developmental math program as the unit of change in the project, not individual faculty, and worked to support faculty in developing the vision and skills needed to implement collectively determined changes. To use Grubb's terminology, we framed the work of the project as practicing "innovation from the middle" rather than strictly "top-down" or "bottom-up." Individual and departmental change are clearly tightly interwoven, as Asera's (2013) interview study of selected faculty who emerged as leaders in the RPM work underscores, but the goal was to move beyond influencing isolated reform-minded faculty to a deeper collective cultural change.

Overarching Project-wide Strategies around Professional Practice

> **...Professional development is particularly important for developmental education instructors, as these individuals tend to have limited previous training for teaching basic skills students. Unfortunately, studies have found that most community colleges provide only episodic staff development activities, which tend to take the form of one-day workshops or seminars led by outside experts, or else informal and isolated conversations among colleagues or departmental meetings that focus on logistics or content knowledge rather than pedagogy. Sadly, studies have revealed that such isolated professional development does little to change individuals' everyday practice, as they become subsumed in normal routines and have little support for integrating new learning into their practice.**
>
> **(Rutschow & Schneider, 2011, p. 66)**

The reform strategies of the RPM project aimed at developing a critical mass of faculty who would acknowledge they share responsibility for the learning in pre-college math with their students and, through of the use of shared protocols and practices, develop effective ways to address those responsibilities, both individually as teachers and collectively as a department or program. In addressing the three specific teaching challenge areas—instructional approaches, faculty role and responsibility, and department culture and innovation—the RPM project focused on creating conditions that supported faculty as learners, with an emphasis not only on how students learn math, but also on how cultures and departments change. This section describes the project-wide activities aimed at addressing these challenges; as noted earlier, for a more specific description of the particular activities and change initiatives undertaken by the colleges involved in RPM, see Appendix B.

Addressing instructional approaches

The use of core practices

The RPM project insisted on the use of strategically chosen common practices designed to generate productive conversations and insights about the relationship between teaching and learning: classroom assessment techniques (CATs), classroom exchanges/observations, and faculty inquiry groups (FIGs). Introducing these common practices provided a foundation throughout the project for jointly building instructional processes, which as Morris and Hiebert (2011) point out, is key to improving classroom instruction over time. The core practices, particularly the use of CATs, were also relatively easy to integrate into existing practice.

RPM gatherings were treated explicitly as opportunities to help faculty learn to use the core practices at their home campuses. In addition to faculty being invited to learn *about* the core practices, they were also invited to learn how to do them *by doing them*, using several different approaches:

Faculty had opportunities to practice using the strategies in a collaborative, supportive setting with helpful and interested peers. Faculty were asked to identify the "muddiest point" (CAT) on several occasions, for instance, on setting up faculty inquiry groups. Faculty practiced observing videotaped classroom sessions and sharing observations with each other. Sessions were organized for faculty to practice reviewing student work together in cross-campus FIGs, with the explicit goal of learning how to facilitate FIGs on their home campuses.

Project leaders checked in with team leads between project meetings about these strands of work. Campus teams appointed one person to be the lead for each of the three core practices. These leads participated in cross-campus phone conferences, signaling the importance of the practice but more importantly, creating opportunities for the sharing of specific strategies that seemed to be working and collaboration around the challenges.

Everyone in the project used a "step-back" consulting protocol. Midway through the grant, we used the "step-back consulting protocol" (Kegan, 2002) as a strategy for problem-solving around the implementation of the core practices on campuses. Representatives from campuses presented a puzzle about the use of any one of the core practices and got structured feedback from colleagues on other campuses.

Project meeting time was allocated to structured reporting on experiences of using the core practices on campuses, including the use of protocols for giving feedback on posters. College teams valued this cross-campus sharing time quite a bit but also appreciated the opportunities provided for team time to connect with each other away from campus on their own work.

The persistent project focus on the use of these practices led to a gradual shift in faculty's attitudes toward them, from a compliance mentality to one focused on the generative outcomes produced by the use of the practices. The project core practices, as a set or on their own, opened up possibilities for classroom-based and collaborative inquiry; they helped make teaching more public, less autonomous and isolated.

The creation of a rich, collaborative, learning environment. Faculty teaching pre-college math courses often do not experience learning environments that support their own professional growth. Recognizing this, RPM created an environment in which faculty were able to learn together and to some extent, direct their own learning. Consequently, many faculty participating in RPM developed stronger grounding in current research on teaching and learning in general and in the teaching and learning of math in particular (Asera, 2013). The following specific strategies facilitated this kind of faculty learning:

Exposure to research-based influential bodies of work.
We allocated time at project meetings for discussion of key articles and for hands-on workshops demonstrating influential, effective approaches to the teaching of math; we also supported groups of faculty attending workshops and participating in an online course, coupled with opportunities to put strategies they learned into practice and reflect with others on the results.

Faculty exchanges. Mandating faculty exchanges as one of the core practices turned out to be very helpful as teachers had opportunities to observe how other people taught. These exchanges often led to conversations that extended over an entire academic year or longer.

Faculty Inquiry Groups (FIGs).
FIGs promoted faculty conversations about student work that elicited meaningful questions about how students came to do that kind of work, which led to further conversation within departments about particular pedagogical approaches. Beyond that, FIGs followed up on shared experiences

(e.g., workshop or RPM Institute experiences) as well as on specific strategies (e.g., conversations about common final questions or the use of and results from specific classroom assessment techniques).

Project-wide sharing about use of class-time. This sharing was framed in part by project leaders' initial observations that most class time was devoted to lecture and in part by discussions of research on learning in early project meetings.

The project also established a resource-rich website, and faculty were regularly asked about what additional areas of learning they wanted to explore. Faculty chose particular practices to pursue through further reading or by attending workshops. When interest in a practice became widespread throughout the project, the practice or the approach was highlighted at a project meeting. Small cross-college groups of faculty were supported in pursuing specific learning interests relevant to the broader project, including the Student Attributes for Math Success (SAMS) project (Balachowski, Luce, Nevins, Palmisano, Walker, & Ypma, 2012), developing a Math Task Library of rich tasks for developmental math courses, Washington Mathematics Assessment and Placement (WAMAP) as an open-resource math assessment platform, and using video cameras to record and review classroom interactions.

Addressing faculty ownership of and responsibility for student learning

A number of colleges have used professional development — usually offered on an optional basis—to educate instructors about how the strategies can best be put in place. But if colleges are serious about implementing desired instructional reforms effectively and on a large scale, they may need to mandate faculty participation, as was done successfully, for example, at Eastern Gateway Community College and South Texas College. Otherwise, it seems likely that those who come forward voluntarily will be individuals who already believe in the reform and are willing to put it in place, or those who can readily be persuaded to become converts to the cause.
(Quint, Byndloss, Collado, Gardenhire, Magazinnik, Orr, Welbeck & Jaggars, 2011, p. 58)

The MDRC report produced by Quint et al. reflects the prevailing narrative in educational reform, especially in the higher education sector: faculty need to be forced into professional learning opportunities or the work will always be limited to a small set of like-minded, already-converted reformers. While there is some value to that perspective—and the RPM project used this "mandatory" approach to some extent in its emphasis on common practices across the colleges involved—the narrative is more complex. Participating in mandatory activities does not guarantee a genuine understanding, let alone adoption, of new approaches or strategies. The real goal is faculty ownership of and responsibility for student learning so that faculty advocate for the professional development they need to improve that learning. To that end, the RPM project invested heavily in professional learning, helping groups of faculty explore strategies together that would have immediate applications in practice as well as support their ongoing, collective learning. RPM established common core practices across the project, but faculty had opportunities to use these practices in ways that made sense in their specific contexts. They had the space to take responsibility for their own learning about how best to support student learning. What the project did insist on, in a variety of ways, was that one of the central questions of the work focused on how much and what kind of responsibility for student learning teachers and departments should bear. The importance of this question was signaled in a number of ways:

Application process
Campus teams interested in applying for the project hosted pre-application visits that included classroom observations. These visits sent a strong signal that classroom practice was a focus for this work. Interested teams had to host departmental conversations about the project prior to applying, including talking about the degree to which they were interested in tackling the challenge of increasing students' success in pre-college math. The application was departmentally based; departments that applied agreed to take responsibility for changing the conditions for student success. They were invited to focus on placement, curriculum and/or pedagogy—all factors over which they had some control.

Site visits and technical assistance
Project leaders regularly asked participating campus teams to share their progress in addressing the challenges related to student success in pre-college math courses. Site visits and technical assistance were designed to support faculty experimentation and shared reflections. They included focused classroom visits, problem-solving sessions, listening sessions, and facilitated workshops, depending on what teams felt best served their needs.

Project meeting times
Project-wide gatherings were held twice a year, for an abbreviated time during the academic year and for a longer time in late summer. At these gatherings, teams reported on the work they were doing, including the ways they were implementing core practices. Sharing among teams was facilitated through structured conversations and informal gathering time. Gatherings included a mix of plenary and break-out sessions, with time reserved for team-specific planning as well. Early on, a project wide norm was established making the investigation of the relationship between teaching and learning a central focus of the work.

Freedom to choose the strategies that made sense in a given context
Faculty at each campus decided together how to implement the core strategies. At one campus, FIGs took the form of regular "reflection Fridays" where colleagues met and talked about student work and developed common questions for final exams. At another campus, a department meeting was turned into a FIG session focused on examining student work coming out of a redesigned course. The RPM project encouraged faculty to choose how and when to use the various core practices in much the same way that faculty were encouraging students to choose from a range of methods to solve problems in math class.

Addressing departmental culture around innovation

A core element of the project theory of change is that student success in pre-college math is directly linked to students' experiences in math classes, and students who experience more engaging, relevant learning are more likely to succeed. The designated common practices—classroom assessments, classroom exchanges, and faculty inquiry groups—were intended to build the capacity of individual teachers, groups of teachers, and ultimately departments, to think critically about the relationship between teaching practices and student learning, with the goal of changing teaching practices in ways that increase student learning.

These common practices took root unevenly and to varying degrees in the math departments involved in the project, but they still led overall to numerous significant but discrete and manageable changes (what Morris & Hiebert, 2011 call "empirical tinkering") in classroom practices. Substantial percentages of both full- and part-time math faculty at the project colleges engaged in one or more project-related activities. In turn, these faculty connected to and learned from each other's work across the college sites through periodic project meetings, campus visits from technical assistance providers and informal "coaches," and the project wiki site: (http://rethinking-precollege-math.wikispaces.com/home).

The colleges were all engaged in addressing these issues to varying degrees; they were not required to do exactly the same things in exactly

the same ways. At the same time, the project encouraged convergence through consistent structured protocols and ongoing technical assistance across the colleges. Over the course of the grant, the goal was to support the college faculty in sharing their work in ways that would help faculty learn from each other and that would encourage the spread of innovations, both within the individual colleges and across the colleges participating in the project.

During the full implementation years of the grant (years two and three), approximately 80 percent of the college sub-grants were invested in supporting faculty engagement for both full-time and part-time faculty. In general the investments took the form of reassigned time or stipends for project leadership, curriculum design, and participation in core activities (faculty inquiry groups, classroom exchanges) as well as support for more traditional professional development activities (consultants, travel, etc.). In that time period, of the 250 or so math faculty (full-time and part-time) across the seven RPM core colleges, roughly three-quarters were involved to varying degrees in some aspect of the RPM work, with some 15 percent of them taking on leadership roles in the work at their colleges.

While limited by the time available in the grant period, RPM succeeded in creating an informal version of what Bryk, Gomez & Grunow (2010) describe as a "networked improvement community"—a network that uses resources, human and technical, in ways that allow the community to get better at getting better. The widespread sharing of practices coupled with the grounding of this sharing in specific classroom practices, observations of students, research on learning and data on student success all contributed to faculty retaining and using the "wisdom of practice" developed together. Faculty began talking about changes in practice they were making, what they were noticing as they made those changes, and what new questions were emerging in the process. Inquiry about teaching, and the relationship between teaching and learning, became the norm, not the occasional exception. Simultaneously, because RPM was a departmentally-based project, there were parallel conversations about how to move ideas forward at an organizational level. Not every effort was successful during the lifespan of the grant; some departments were moved to support change through a mix of bottom-up, mid-level and top-down pressures, but for a variety of reasons not all departments made the same amount of change over the course of the project. For more specifics about the departmental changes within RPM, see Appendix B.

Conclusions:

What the RPM Project Says about "Re-Thinking Pre-college Math"

Faculty perspective

Given the emphasis in the project on honoring the critical role of faculty in designing, supporting, and sustaining meaningful reforms in pre-college math, it seemed fitting as the grant wrapped up to consult the faculty most deeply involved in the work in order to solicit from them the most effective strategies addressed in their projects. Just as faculty were involved from the very beginning in developing their local college efforts, it was critical to acknowledge their expertise in reflecting on and analyzing what happened in the project in terms of successes and challenges. To harness and shape that expertise, RPM structured a significant portion of the final and crucial project-wide institute around a set of broad areas based both on the overall project focus (keeping the three central questions of core educational practices in mind) and on more specific themes that had emerged from campus visits and interviews as part the formative evaluation efforts over the course of the grant: structural redesign; organizational and departmental context; **instructional practices/professional roles; and student behaviors/perspectives.**[x]

For the "structural redesign" section of the institute, the colleges were asked to provide a visual description of what they had chosen to do with their pre-college math programs and to focus their description on analyzing the role and significance of such redesign work for the deeper focus of the project: Why/how do changes in curricular structures matter? What do such changes allow you to do, and how do they relate to other critical improvements in pursuit of student success? What's the connection between the structural changes and improving student engagement or increasing mathematical understanding?

The institute framed and addressed each of the other emergent themes through a series of consistent questions aimed at developing a collective understanding among all participants about what had been most successful (and not so successful) in their local projects. The goal was to have faculty who had been engaged in the work identify *which of their project activities and strategies had made the most significant contribution to their overall progress toward improved student learning and success in pre-college math*—based on evidence, not on assumptive beliefs about what should work. By the end of the institute, the project leadership had gathered a rough set of recommended strategies and provided the college teams with some time for reflecting on which strategies were potentially most valuable in moving forward with the work around pre-college math in their particular institutional contexts.

Following the summer institute, the leadership group refined and organized the rough drafts of the recommended strategies, then convened a small sub-group of faculty leaders from each of the project colleges to review, re-organize, and prioritize the revised set of recommendations. The final recommendations presented below represent the work produced by that group. While not every faculty member involved in the RPM work across all seven colleges would necessarily agree with every item noted here, the list does reflect a solid consensus from the RPM faculty leaders with the deepest engagement in the work of the project.

While implementing and sustaining these recommendations is still very much a work-in-progress, details and specific examples from the RPM colleges can be found on the project wiki site, accessible through the Transition Math Project portal (http://transitionmathproject.org/).

- What math do we teach (and why)? Changing curricular content and structure

  1) Define course outcomes based on the mathematics students actually need for success in college and in their lives.

  2) Courses should not be defined as simply a collection of topics; they should provide explicit opportunities to develop deep and enduring mathematical understanding of core themes (e.g., ratio, linear, quadratic, and exponential growth/decay) and connections between topics.

  3) Multiple course pathways are more effective than a "one-size-fits-all" curricular approach in helping a diverse student population achieve comparable goals relevant to their individual lives.

- How do we teach? Making significant but manageable changes in instructional practices

  1) Use classroom time to provide students with rich, open-ended tasks that promote mathematical understanding. Features of such tasks include mathematical reasoning, multiple representations, and a focus on sense-making, offering opportunities for students to communicate and justify their understanding to each other and not just to the instructor.

  2) Emphasize contextual applications that promote personal connections to the learning.

  3) Embed timely and practical activities that explicitly relate learning skills and student attributes to learning mathematics, in order to build student self-reliance and change students' mindset about themselves as math learners. These skills and attitudes include persisting on tasks in productive ways, applying note-taking and textbook reading skills that are specific to mathematics, and a willingness to take risks and engage in problem solving, etc.

- How do we know students have learned the math? Improving assessment strategies to support and reinforce engagement and understanding

    1) The assessments used should reflect and align with the instructional approaches, outcomes, and content of the course.

    2) Using frequent and ongoing classroom assessments focused on feedback to students provides meaningful and low-stakes opportunities for learning both for students and instructors, telling students what they know now and providing guidance on what they can do to improve while informing the teacher's instructional strategies and choices.

    3) Students should be offered multiple ways to demonstrate knowledge and mathematical competence both in class and out of class.

    4) Common assessment items (across sections and/or courses) are a critical component in departmental inquiry and iterative systematic program improvement.

- How can the department and/or program support faculty in making these changes?

    1) Make student (and faculty) learning a key driver in departmental decision-making (e.g., scheduling, class assignment, professional development opportunities, collaboration time).

    2) Create department-wide opportunities for collaborative faculty inquiry focusing on student work using structured protocols.

    3) Provide all interested instructors (adjuncts and full-time) with resources such as time, space, and support to explore new teaching and learning approaches through strategies such as classroom exchanges and regular focused evidence-based discussions of student learning.

    4) Reinforce faculty respect for each other as professionals (and avoid pitfalls such as placing blame) through well-structured classroom exchanges and regular substantive discussions around student learning.

■ How can the college support and sustain these changes in pre-college math over time?

1) Support and empower the mathematics department as a whole in using their professional judgment to improve pre-college success rates and recognize publicly their efforts to do so.

2) Use internal and external resources (both money and expertise) to advance faculty learning and support leadership growth.

3) Hire for the department you want to create; support the hiring of faculty (tenure and non-tenure tracks) who have backgrounds in and a commitment to educational improvement and developmental coursework.

4) Create a trusting environment with increased transparency and clarity regarding results with a focus on encouraging innovation and promoting student learning.

5) Support institutional researchers in helping faculty investigate success of reforms at a level of detail sufficient to make warranted inferences and revisions.

6) Work with registration, student services, advisors, and other related college functions to support changes to courses.

Project leadership perspective

In addition to this critical faculty perspective on the lessons of the Re-thinking Pre-college Math project, the authors of this report (as the leadership group for the overall project) bring a meta-perspective on what seemed to be the most significant lessons of the project: what made the most difference in terms of supporting and sustaining faculty and math departments in their efforts to address the over-arching project goals of increased student engagement and deeper student understanding of key mathematical concepts? The following set of recommendations represents the considered reflections of the leadership group about how best to approach this kind of comprehensive re-thinking of pre-college math programs in community and technical colleges.

- Address core beliefs and perspectives about math, students, and learning that shape instructional practice.

Serious and sustained improvement in student college and career readiness in mathematics requires an intentional focus on influencing teacher beliefs and behaviors around Elmore's (1996) "core of educational practice": subject matter (including critical concepts and methods of inquiry related to that math content), student learning (especially the ways in which students' mathematical thinking develops), and teaching practice (the nature of and effects of various instructional approaches). Structural reforms are unlikely to be successful or sustained for enough time to be institutionalized without addressing these core beliefs and behaviors. From the anecdotal evidence gathered at the final project Institute, faculty describe some significant shifts in their thinking as a result of their experiences in the project (see Appendix D for a sampling of these comments); the project evaluation report (Davis, 2013) will provide a more in-depth exploration of the extent and nature of these shifts.

- Develop among faculty in pre-college math programs shared understandings (about program goals, mathematical competency, student learning, etc.) and a sense of collective responsibility for student success in math.

Faculty generally are more likely to support and sustain change initiatives over time if they can personally "own" the work by designing and refining the implementation of such efforts rather than having them imposed from the outside. That said, shared understandings—about the work and the nature of the responsibility for student learning—matter a great deal; the real issue is the most appropriate level for forging such shared agreements. The RPM project encouraged and promoted wider common ground among faculty across colleges, but the most critical place we pushed for agreement was at the level of the college math department or pre-college math program. Creating a workable consensus among even a critical mass of faculty in a college math department or pre-college math program is a difficult and time-consuming challenge, but working toward that end at the RPM colleges has produced some success in creating more ownership and energy around change work than would have been possible with top-down mandates or policy levers alone.

- Pursue collective inquiry through structured protocols and common practices around instruction and assessment with an emphasis on increasing student engagement and improving mathematical understanding.

Changing core beliefs and perspectives about math, students, and learning is extremely difficult, particularly in any direct way. RPM addressed these shifts with some success through a focus on shared practices that provided the basis for ongoing faculty inquiry and professional learning. Engaging faculty in these practices was most effective when structured with flexible protocols that guided discussions in productive ways.

- Acknowledge that the critical elements (content, instruction, assessment) of re-thinking pre-college math are interconnected and can't be addressed in isolation.

While the approach RPM took focused heavily on pedagogy—to correct a perceived imbalance in the typical approaches taken with this kind of reform work—it would be as much of a mistake to focus exclusively on what individual teachers do as to focus solely on implementing new curricular structures. Pre-college math programs (and classrooms) represent a complex ecosystem of interacting components and they can only be fully understood and improved when approached as such, with understanding faculty perspectives and student learning central to that process.

- Emphasize faculty making meaningful but manageable changes in the core areas of instructional practice related to classroom teaching and assessment.

Within the context of the structural curriculum changes implemented by the colleges involved in the project, RPM focused its interventions on classroom changes in faculty practices related to instruction and assessment. As Dylan Wiliam (2006) has noted, any more than a handful of such changes in a given year can be overwhelming for teachers and can undercut any efforts to shift their practice and their perspectives in ways that support greater student learning. The RPM project encouraged faculty to implement small but still potentially significant changes in their classrooms as a way of keeping the effort manageable and being able to study the impact of these changes and make adjustments as needed.

- Develop and support teacher leaders in promoting and sustaining change initiatives in order to address issues of "scaling" innovations over time.

"Scaling" innovations—creating conditions for multiple faculty and multiple colleges to adapt and implement successful improvement strategies—has proven to be one of the most complex and challenging issues facing educators in addressing long-term problems related to student achievement. As Cynthia Coburn (2003) has noted, scale involves more than just multiple sites "adopting" a particular strategy or program. Meaningful "scaling up" can also involve improving the depth of understanding of core principles within an educational institution; sustaining and supporting substantive change over time; spread both within a school or college as well as across institutions; and a fundamental shift in knowledge about and capacity for extending the reform work. This kind of scaling requires developing and nurturing internal faculty leaders within departments as an essential component of sustaining the momentum of any meaningful reform effort over time.

- Promote a culture of improvement and innovation, both within and across colleges, encouraging faculty to learn from, and share publicly, experiments in teaching and learning.

A critical reason that scaling innovations has been so difficult is that many projects are well-supported initially but then rarely managed actively enough to engage faculty in making and sustaining the complex shifts required to change practice (Elmore, 2006). The coordination and connections provided by a diverse and interdisciplinary statewide leadership group allowed RPM to a) offer ongoing trouble-shooting aimed at the challenges of making changes in departmental and instructional practices, b) extend technical assistance, c) promote some consistency around the common practices addressed in the project, and d) leverage the local work of the colleges so that faculty across the project could showcase and learn from the variety of innovative home-grown practices that showed some success. Providing faculty access to, and structuring their engagement with, this broader support system—the "networked improvement community" noted earlier—is a crucial element underlying the success of any large-scale reform initiative.

Summary:

Shaping the Culture, Creating the Conditions for Change

At the moment there seems to be at least a rhetorical sense of urgency about dramatic changes in education, both in broad terms and specifically in the area of pre-college mathematics. There is a consensus among many policymakers and funders that the current model of pre-college or developmental education is broken beyond repair and needs revolutionary, disruptive changes rather than evolutionary, incremental progress. While disruptive innovations, particularly in how emerging technologies can be effectively integrated into the fabric of education, have a meaningful role to play in moving education forward, it is important to recognize, as Sir Ken Robinson (2010) has argued, that in order to truly revolutionize education, educators need to abandon the long-standing industrial model of education (and reform). Rather than scaling up clearly defined technical solutions, Robinson argues for a model framed by an agricultural metaphor, establishing an organic process in which education leaders create the conditions for faculty to fully use their talents and produce their own solutions to the classroom learning challenges they face, within a shared framework focused on a clear set of common ends. Like Parker Palmer (1992) argued with respect to assessment and education reform, Robinson proposes that what education really needs is a "movement" in which educators, with significant external support, develop their own solutions customized to local conditions and needs.

While the relatively short time frame of the RPM project makes it difficult to assess fully the extent to which project activities have addressed its long-term goals of increased student engagement and deeper mathematical understanding, much less assert that it represents an educational "movement," Parker's and Robinson's notion is the spirit and framework within which we pursued the work, and we believe there are positive signs of progress. The evaluation evidence gathered to date and the companion faculty study (Asera, 2013) suggest strongly that the project has been successful in influencing faculty behaviors and perspectives so critical to achieving the longer-term project goals. The project has produced a number of emerging faculty leaders across the cohort of colleges, faculty committed to working with their colleagues around what they have learned through RPM and the departmental changes they have put into place. We believe those leaders can be the genesis of the math reform movement that is needed, and we are committed to finding ways to support them in their continuing efforts to shape their department and college cultures in ways that make a meaningful difference for student learning in mathematics.

References

Asera, R. (2011). *Innovation at scale: How Virginia community colleges are collaborating to improve developmental education and increase student success.* Boston, MA: Jobs for the Future.

Asera, R. (2013). *Unpacking professional development: Mathematics faculty reflections on rethinking pre-college math. Olympia,* WA: Washington State Board for Community & Technical Colleges.

Altstadt, D. (2012). *How states can accelerate community college innovation by supporting faculty leadership.* Boston, MA: Jobs for the Future.

Attewell, P., Lavin, D., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education.* 77, 5, September/October 2006, 886-924.

Bailey, T. (2009). *Rethinking developmental education in community colleges.* Community College Research Center Brief, # 40, February 2009. New York: Teachers College, Columbia University.

Balachowski, P., Luce, M., Nevins, M., Palmisano, E., Walker, C., & Ypma, H. (2012). *Got SAMS? Student Attributes for Math Success.* Olympia, WA: State Board for Community & Technical Colleges.

Bass, R. (1999). The scholarship of teaching: What's the problem? *Inventio, 1,* 1, February 1999.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school (Expanded edition).* National Research Council Committee on Developments in the Science of Learning. Washington, D.C.: National Academies Press.

Bryk, A. S., Gomez, L.M., & Grunow, A. (2010). *Getting ideas into Action: Building networked improvement communities in education.* Stanford, CA: Carnegie Foundation for the Advancement of Teaching.

Coburn, C. (2003). Rethinking 'scale': moving beyond numbers to deep and lasting change. *Educational Researcher,* 32, 6, August/September, 2003, 3-12.

Collins, M. (2009). *Setting up success in developmental education: How state policy can help community colleges to improve student outcomes.* Boston, MA: Jobs for the Future.

Collins, M. (2011). *Driving innovation: How six states are organizing to improve outcomes in developmental education.* Boston, MA: Jobs for the Future.

Complete College America. (2012). *Remediation: Higher education's bridge to nowhere.* Washington, D.C.: http://www.completecollege.org/

Couturier, L. (2012). *Cornerstones of completion: State policy support for accelerated, structured pathways to college credentials and transfer.* Boston, MA: Jobs for the Future.

Cox, R. (2010). *The college fear factor: How students and professors misunderstand one another.* Cambridge: Harvard University Press.

Donovan, M. S. & Bransford, J.D. (*Editors*). (2005). *How Students Learn: Mathematics in the Classroom.* National Research Council Committee on How People Learn: A Targeted Report for Teachers. Washington, D.C.: National Academies Press.

Elmore, R. (1996). Getting to scale with good educational practice. *Harvard Educational Review*, 66, 1, 1-27.

Elmore, R. (2006). *Improvement of teaching at scale.* NSF Learning Network conference, January 2006. Retrieved from http://media.mspnet.org/conferences/06lnc/06relmore/transcript/index.htm)

Givvin, K., Stigler, J., & Thompson, B. (2010). What community college developmental mathematics students understand about mathematics, Part 2: The interviews. *MathAMATYC Educator,* 2, 3, May 2011.

Grubb, W. N., Boner, E., Frankel, K. , Parker, L., Patterson, D., Gabriner, R., Hope, L., Schiorring, E., Smith, B., Taylor, R., Walton, I., & Wilson, S. (2011). *Basic skills instruction in community colleges: The dominance of remedial pedagogy.* Working paper # 2. Stanford, CA: Policy Analysis for California Education.

Grubb, W. N., Boner, E., Frankel, K. , Parker, L., Patterson, D., Gabriner, R., Hope, L., Schiorring, E., Smith, B., Taylor, R., Walton, I., & Wilson, S. (2011.) *Innovation in developmental education: The landscape and the locus of change.* Working paper # 3. Stanford, CA: Policy Analysis for California Education (PACE).

Hern, K., with Snell, M. (2010). *Exponential attrition and the promise of acceleration in developmental English and math.* Hayward, CA: Chabot College.

Hodara, M. (2011). *Reforming mathematics classroom pedagogy: Evidence-based findings and recommendations for the developmental math classroom.* CCRC Working paper # 27, Community College Research Center *Assessment of Evidence Series.* New York: Teachers College, Columbia University.

Humphreys, D. (2012). What's wrong with the completion agenda—and what we can do about it. AACU, *Liberal Education,* 98, 1, Winter 2012.

Kegan, R. (2002). *Step-Back consulting (background from the Harvard Macy Institute).* Retrieved from http://www.casemed.case.edu/curricularaffairs/scholars/2009%20Materials/022708/Step-Back%20Consulting%20Process.doc

Morris, A. K. & Hiebert, J. (2011). Creating shared instructional products: An alternative approach to improving teaching. *Educational Researcher,* 40, 1, 5-14.

National Center for Postsecondary Research. (2010). Developmental education: What policies and practices work for students? Retrieved from http://www.postsecondaryresearch.org/conference/

National Center for Postsecondary Research. (2012). Strengthening developmental education: What have we Learned, and what's next? Retrieved from http://www.tc.columbia.edu/ncpr2012/

Palmer, P. (1992). Divided no more. *Change Magazine,* 24, 2, 10-17, March/April 1992. (available at http://www.couragerenewal.org/parker/writings/divided-no-more)

Quint, J., Byndloss, C., Collado, H., Gardenhire, A., Magazinnik, A., Orr, G., Welbeck, R,. & Jaggars, S.S. (2011). *Scaling up is hard to do: Progress and challenges during the first year of the Achieving the Dream Developmental Education Initiative.* New York: MDRC.

Robinson. K. Bring on the Learning Revolution. TED Talk, May 24, 2010. Retrieved from http://www.ted.com/talks/sir_ken_robinson_bring_on_the_revolution.html

Rutschow, E.Z. & Schneider, E. 2011. *Unlocking the gate: What we know about improving developmental education.* Oakland, CA: MDRC.

State Board for Community and Technical Colleges. (2012). Role of pre-college (developmental and remedial) education 2009-10 public high school graduates who enroll in Washington community and technical colleges in 2010-11. SBCTC *Research Report 12-2*, December 2012. (http://www.sbctc.ctc.edu/college/education/12-2RoleofPre-CollegeEduc_000.pdf)

Shulman, L.S. (2000). Teacher development: Roles of domain expertise and pedagogical knowledge. *Journal of Applied Developmental Psychology,* 21(1), 129-135.

Stigler, J., Givvin, K., & Thompson, B. (2010). What community college developmental mathematics students understand about mathematics. *MathAMATYC Educator,* 1(3), May 2010.

Tinto, V. (2012). *Completing college: Rethinking institutional action.* Chicago, IL: University of Chicago Press.

Wiliam, D. (2006). *Assessment for learning: Why, what and how.* Edited transcript of a talk given at the Cambridge Assessment Network Assessment for Learning Seminar, September, 2006 at the Faculty of Education, University of Cambridge. Retrieved from http://www.dylanwiliam.org/Dylan_Wiliams_website/Papers.html

Endnotes

[i] See http://www.transitionmathproject.org/ for details on the Washington Transition Math Project (TMP).

[ii] This visibility has spawned national conferences (National Center for Postsecondary Research 2010, 2012), numerous broad reform projects, both national (e.g., Developmental Education Initiative (http://www.deionline.org/), Completion by Design (http://completionbydesign.org/), Change the Equation (http://changetheequation.org) and state-specific (Asera, 2011; Collins, 2009), along with a cottage industry of research studies and project reports (e.g., Couturier, 2012; Quint et al, 2011; Rutschow et al, 2011).

[iii] See http://www.vccs.edu/Portals/0/ContentAreas/AcademicServices/The_Critical_Point-DMRT_Report_082010_pdf.pdf

[iv] See http://www.carnegiefoundation.org/developmental-math

[v] The most recent salvo offering sweeping solutions to pre-college education is the December 2012 statement from Complete College America, released in conjunction with the Charles Dana Center, Education Commission for the States, and Jobs for the Future: http://www.completecollege.org/docs/Remediation_Joint_Statement-Embargo.pdf , calling in part for math content aligned to students' academic programs of study, accelerated pathways, more students directly enrolled (with added support) in college-level courses, "meta-majors," and multiple measures for guidance and placement.

[vi] Quote retrieved from http://www.brainyquote.com/quotes/quotes/h/hlmencke129796.html#4GFyeziuFOYM1w9b.99. (http://www.aacu.org/liberaleducation/le-wi12/humphreys.cfm)

[vii] http://www.carnegiefoundation.org/scholarship-teaching-learning and http://www.issotl.org/

[viii] For an interesting consideration of the "problems" of scholarship around teaching and learning, see Bass (1999), available at http://www2.okcu.edu/cetl/randybass.pdf

[ix] http://www.wamap.org, also accessible through the Transition Math Project site: http://www.transitionmathproject.org

[x] See Appendix D for a fuller description of these areas.

[xi] Some examples of specific classroom activities with this focus can be found in the got SAMS? workbook, available through the Transition Math Project web portal: http://transitionmathproject.org/

[xii] Examples of this thinking are almost too numerous to mention, but Clayton Christensen (http://www.claytonchristensen.com/) is one of the more popular proponents; see http://www.cnbc.com/id/46760210/CEO_Blog_We_Need_Disruptive_Technology_in_Our_Classrooms for another example.

[xiii] Mickey Davis, a co-author of this report, has conducted extensive qualitative and quantitative evaluations of both faculty and students perspectives in the context of RPM; his formal evaluation report will be published in March 2013.

[xiv] For more details about I-BEST, see http://www.sbctc.ctc.edu/college/e_integratedbasiceducationandskillstraining.aspx

Appendix A

Descriptive Background of Project

The *Re-Thinking Pre-college Math* (RPM) project was part of the larger Washington State Student Completion Initiative awarded to the State Board for Community and Technical Colleges by the Bill & Melinda Gates Foundation in late September 2009. The three-year grant (roughly 5.5 million dollars overall) was focused on supporting new and promising efforts to improve access and completions for low-income young adults in Washington State, helping to break down key barriers to student completion in the community and technical college system by funding three projects:

1) *Open Course Library:* expanding access and success in 81 high-enrollment courses by lowering textbook costs for students, providing new resources for faculty, and improving course completion rates.

2) *I-BEST for Developmental Education:* developing models at ten colleges designed to extend the pathways developed in currently approved I-BEST (Integrated Basic Education and Skills Training) programs that are at least two quarters in length.

3) *Re-Thinking Pre-College Math* project: improving student completions in pre-college mathematics courses and their success in college-level math classes.

RPM built on the successes and lessons from the Washington *Transition Math Project* (TMP), shifting the focus of the intervention from high schools and the transition to college to the pre-college (aka developmental) math programs in Washington community and technical colleges. The RPM project was designed to improve success and mathematics college readiness for students in developmental math, measured in terms of student **performance and persistence** (see Appendix C for details of the quantitative evaluation data on the project), by taking a faculty-driven and college-centered approach to re-thinking developmental math programs. In order to make any progress on the long-term student outcomes within the time constraints of the grant funding (fall 2009 through fall 2012), the project focused on some critical intermediate outcomes around curricular structures and teacher behaviors/beliefs as essential levers for producing those outcomes. A crucial aspect of the learning from this project involves understanding more fully the processes and challenges involved in taking these changes in structures and behaviors/beliefs to scale, both within a college math department and across multiple colleges in a system.

The broad goal was to encourage and support a coalition of community and technical colleges in efforts aimed at improving their developmental math programs in fundamental ways. These efforts were specifically targeted at substantive changes in core educational practices (curriculum, instructional practices, and assessment) designed to **increase student engagement and deepen student mathematical understanding.** Participating institutions were selected based on their capacity to build on existing work, assemble an appropriate team of faculty and instructional leaders, and engage part-time faculty in the project. The intent was to have a solid commitment from the college's math department collectively, not just from individual and isolated math faculty interested in changing their own classrooms.

Appendix B

Highlights of Individual College Project Activities

1. Spokane Falls Community College (http://www.spokanefalls.edu/)
Faculty contact: Pete Wildman (petew@spokanefalls.edu)
Prior to receiving the RPM grant, SFCC had received a Title III grant to “redesign” the course content of the three-course developmental algebra sequence. The redesign did not alter the number of courses offered in the program; instead, it created three new courses designed to better match the Washington college readiness math standards. The first course (Math 93) focuses on linear functions, the second course (Math 94) on quadratic and radical functions, and the third course (Math 98) on logarithmic and exponential functions. Additional content changes included an incorporation of graphing technology, a multi representational approach and a focus on developing student attributes. The RPM project, begun during the third year of the Title III grant, helped support the first and second year of full implementation of the new sequence. Additional departmental changes included fewer but slightly longer classes to provide students more processing time during the week to handle difficult concepts and a new custom placement test to better place students in developmental courses.

The redesign has resulted in a greater number of students succeeding in the developmental courses. This is especially true for those students who get past the first course in our sequence. Math 94 has a success rate of around 65-70 percent; Math 98, 75-80 percent. These are significantly higher than these courses prior to the redesign. Math 93 has seen some increase in success rates, but not as dramatic as in the other two courses. Because the structural changes were made prior to receiving the RPM grant, RPM-supported activities concentrated more on evaluation issues and on pedagogical changes to be infused into the new courses with an emphasis on incorporating approaches learned from Ruth Parker’s Mathematics Education Collaborative (http://www.mec-math.org/) workshops sponsored by RPM.

2. Highline Community College (http://www.highline.edu/)
Faculty Contact: Helen Burn (hburn@highline.edu)
The RPM project enabled the college to implement fully a new pre-college curriculum which makes it possible for most students needing pre-college math courses to reach and complete their college math course within one year. The new curriculum places many of the technical topics used almost exclusively by STEM major students, such as simplifying and solving radical expressions and equations, into a pre-college course (Math 98) taken only by students needing calculus. The two courses in the main sequence for all students (Math 81 and 91) start with basic signed numbers and fractions, take an early functions approach, and leverage the MyMathLab online technology for skill building and rapid feedback to students. In addition, these two courses have students applying mathematics in meaningful contexts and examining their own habits and attitudes related to learning.

As part of the project the department required faculty to use common assessments and submit their results for analysis, including course-level retention and pass rates. This began with common mastery exams on key topics which students must pass at an 80 percent level, with no partial credit, to be eligible for passing the course. It has recently expanded to the inclusion of a small set of common questions as part of each instructor’s final exam. Though the use of common final exam questions is not mandatory, most instructors voluntarily participate.

Through RPM the department established “lead instructors” for the developmental courses. These instructors support other faculty by answering questions about, providing models for, and facilitating discussion of teaching and assessment in specific classes. They also encourage consistency across sections by reviewing syllabi and overseeing the administration of and reporting about common assessments. This has produced a team approach and sense of shared responsibility around the developmental math courses.

Critical administrative changes that have supported the reform include assigning faculty to courses on an annual basis, rather than quarterly. By doing this for full-time faculty, it became possible to essentially guarantee adjunct faculty specific courses and levels of employment. Adjunct instructors reported an increased willingness to invest time and energy into examining and improving their pedagogy since they know they will have an opportunity to use the results.

While not explicitly part of (or funded through) the RPM grant, the department has revised its procedures for placing students into courses. The nontraditional arrangement of content increased the need for a more customizable alternative to the COMPASS placement test and led to conversations with local school districts about improving our policies for placement using high school transcripts.

3. Everett Community College (http://www.everettcc.edu/)

Faculty Contact: Mike Nevins (mnevins@everettcc.edu)

Major departmental changes undertaken as part of the RPM project:

- Math 98: Intermediate Algebra in Context was developed as an alternative to the previous intermediate algebra course (Math 99). The new course covers intermediate algebra topics with a focus on modeling real data sets and project-based assessment and is currently intended only for non-STEM students.

- Math 91 and 92 were developed as an alternative to the previous Math 81/82/99 sequence offered at EvCC. The purpose of the Math 91 and 92 curriculum is to remove the overlap of topics in the former sequence and shorten our students' path to college-level mathematics. These courses were piloted in winter 2011; beginning fall 2012, they replaced the previous sequence as the main algebra pathway through developmental mathematics.

- Beginning fall 2012, a new self-paced review course of arithmetic and algebra concepts in a computer-mediated lab setting (using ALEKS software-- http://www.aleks.com/) is being offered in the Math Learning Center (MLC). Through this course students have the opportunity to gain the pre-requisite knowledge and skills for any of the pre-college math courses. When they demonstrate this knowledge, students are directly placed into the given course without needing to retake a placement test. The goal of Math 79 is to offer students an opportunity to move as quickly as possible through developmental mathematics. ALEKS has two important features that allow students to quickly review arithmetic and algebra topics. First, ALEKS begins each student at a point in the curriculum that matches the student's current understandings (via the initial assessment test). Second, ALEKS offers students the curriculum in a non-linear manner. Thus, students have several different topic areas to work through at any one time. If a student is struggling with a certain concept, they are not kept from working on different concepts (as is the case with most linearly progressing curricula).

- Along with the implementation of Math 79, an articulation agreement has been made between the ABE (adult basic education) department and the math department. Students completing HSC 014, an arithmetic course within the ABE department, are now allowed to enroll in Math 80 (Pre-Algebra) without re-taking the placement test. The math department has agreed to advise students, who place into arithmetic, but are wary of a self-paced, computer-aided learning environment (as offered in Math 79), into HSC 014. Also, the math department has agreed to accept certain scores on the GED exam as placement into the developmental sequence. These changes are intended to provide students completing ABE courses an obvious path into the developmental sequence.

- The Alternative Placement Model, based on Green River Community College's model, was implemented fall 2011. This placement model allows students to use their high school transcripts (from local high schools) to place into math courses at Everett Community College. This model provides students an alternative to the score they receive on their COMPASS placement test and often places them higher in the math sequence than their COMPASS placement. Through this process advisors at Everett have been able to quickly and efficiently advise students unhappy with their COMPASS placement. Assessment of this placement model is ongoing but the initial feedback received regarding the model has been positive.

4. *North Seattle Community College* (https://northseattle.edu/)

Faculty Contacts: Deanna Li (dli@sccd.ctc.edu); Edgar Jasso (ejasso@sccd.ctc.edu)

Major departmental structural changes undertaken as part of the RPM project:

- One of the most often cited structural changes due to the RPM project is the math faculty biweekly gathering called "Reflection Friday." It is a support group for faculty as well as a forum where faculty can exchange ideas. Reflection Friday has encouraged faculty to try new ways of teaching, challenged us to use different methods of assessments, and most importantly, got us talking about student learning and student attributes in order to promote student success.

- The department has developed and begun offering every quarter, a Basic Math course linked with a math study skills class that helps students understand their learning style, manage their math and test anxieties, improve their study skills, etc. in order to advance their math performance. There are some students who definitely benefit from the link. However, because of individual class scheduling constraints, some students are forced to enroll in this link. It then becomes a challenge to teach students who are not interested in the study skills portion of the link. Analysis of this link's success rate is still incomplete but it has become a top priority for the college administration as part of an overall student success agenda.

- Beginning Algebra I/II and Intermediate Algebra textbooks have shifted from a very traditional one to a text that blends a traditional approach with more contextual material. One of the rationales for this change is to get more faculty to try some of the RPM approaches and strategies for deepening student understanding discussed at the ongoing "Reflection Friday" faculty gatherings.

- RPM has encouraged the math department to try new ways to shorten our precollege math sequence. As an option for students to accelerate into college level math in two quarters, Beginning Algebra I and II are now offered every quarter, including summer, as a single 10-credit combination class, meeting two hours each day for students who wish to and are able to do an intense course of Beginning Algebra.

- RPM has encouraged experimentation with linking the Intermediate Algebra course with a science subject, offering a science-math hard link course every fall and spring quarter for the past two years, including Environmental Science, Chemistry, and soon, Astronomy. Faculty are learning that for technical reasons some pairings work better than others—Chemistry was not very successful, for instance but the Environmental Science link worked beautifully to the point that some students have shifted from a non-science major to an Environmental Science major. Overall, whether the pairings blended well or not, students come out of the class with a better appreciation of how math is used in the sciences.

5. *Lower Columbia College* (http://www.lowercolumbia.edu/)

Faculty Contact: Dawn Draus (ddraus@lowercolumbia.edu)

Prior to the grant the pre-college mathematics program consisted of four 5-credit courses. Much of the content in these courses overlapped. Through the RPM project LCC removed the obvious overlap and condensed the sequence to three 5-credit courses. The department then split each of these courses into 3 and 2 credits "halves," allowing the unsuccessful student to pass a portion of their course rather than failing the entire course. Further, the split allows for increased options for initial placement in the sequence as well as multiple exits points for students based upon the needs of subsequent coursework and/or degree requirements. Current data shows that student success in our pre-college math courses under the new 15 credit curriculum is at or better than previous rates under the 20 credit curriculum.

LCC replaced COMPASS for placement with a "home-grown" series of assessments in Pearson's MyMathTest. Mathematics faculty at LCC wrote these assessments with the college's specific course content in mind. Students can now place anywhere from the lowest course offered up through Calculus I. Practice tests for both the online system and mathematical content have also been built into the new assessment.

LCC replaced the old self-paced Math Lab with a "Math Achievement Center" that is a comfortable, welcoming environment where all pre-college math students can get help on homework and review for exams. Online support for self-paced learners was also redesigned, with clearly defined "learning pathways" in the online course spaces guiding students through the many support options available in Pearson's MyMathLab.

Building on the reform effort, Lower Columbia College has undertaken several new, related initiatives under the auspices of Achieving the Dream, including: math boot camps to help students prepare for placement assessment; strengthening of local K-12 partnerships to align curriculum and broaden high school math transcript placement agreements; development of online courses in pre-college math to broaden student access; and exploration of a possible Online Open Course (a variation on the MOOC concept) to provide pre-college math skill refreshers to interested students and community residents.

6. Clark College (http://www.clark.edu/)

Faculty Contact: Bill Monroe (bmonroe@clark.edu)

As part of the RPM project faculty developed an alternative approach to teaching Beginning Algebra (Math 089) that reflects current best practices in teaching. These classes are using an inverted ("flipped") classroom model that shifts much of the direct instruction component of the class from in-class lectures to out-of-class "homework" accessing online resources (videos, practices, problems, etc.). This shift allows for more time to be spent in class on challenging problems and student group work. Classroom activities require students to share their thinking within groups and to the class as a whole. Many units utilize menus of problems and reflect the strategies supported by the training sessions provided by Ruth Parker. These classes are offered in two two-hour blocks twice a week and one one-hour block on Friday.

A second RPM-related initiative is the Math Academy, a student learning community that began fall 2012. The goal of the Academy is to provide a cohort of students with the focused support needed to complete their three-course developmental math sequence in one year. Each of the Academy courses is linked to a math lab providing support to the student cohort for the daily lesson as well as a reinforcement of fundamental math skills. Students will also learn more about effective ways to study math.

Many teachers involved with the grant report that the most important change due to the RPM work was the collaboration that occurred between teachers as they developed various forms of formative assessment tools and visited each other's classes. Most of this experience originated from the FIG (Faculty Inquiry Group) meetings and associated activities. During these meetings, conversations about student assessment, student engagement and learning led to an open-ended and ongoing professional conversation between the teachers that stimulated deeper contemplations of their roles as educators leading to sustained efforts to improve their teaching.

In a sense the FIG activities have spawned an educational community where ideas can be shared and tested. Teachers often create a lesson or an assessment, bring it to the FIG meeting and share it with their colleagues. On many occasions, other faculty then adapted these materials and reported on their experiences to the colleagues at the next meeting. This type of activity was particularly helpful to the participating adjunct teachers who comprise the majority of the RPM participants.

Several RPM team members comprise the Assessment Committee for the pre-college math courses. This work is part of a campus wide initiative to provide programmatic assessment for our students. We anticipate that the work on developing assessments for pre-college math will form a basis for testing the efficacy of new methods of instruction within the department.

7. ***Northwest Indian College*** (http://www.nwic.edu/)
Faculty Contact: Matteo Tamburini (mtamburini@nwic.edu)
Major departmental structural changes undertaken as part of the RPM project:

- Revised the outcomes for the two pre-college math courses, identifying topics that were being covered "because they are in the book" and systematically eliminating some topics that we deemed unnecessary, thus leaving more time for the remaining core topics.

- Focused on strategies for incorporating culturally relevant processes and content throughout the math curriculum, including the developmental math classes; one important observation is that Ruth Parker's patterns could easily be adapted to traditional beading or weaving patterns.

- Began using the Washington Mathematics Assessment and Placement (WAMAP) site to replace the previous placement test (COMPASS) and offer a new placement test aligned to the new curriculum.

- Incorporated multiple strategies from Ruth Parker's workshops in the first quarter of algebra, using some of the class time saved by eliminating other material to offer a menu-type setting to students, adapted from Parker's work, and using that menu approach to add the concept of linear functions.

- Adopted as a college the idea of faculty inquiry groups (FIGs) and somehow institutionalized it to the whole faculty, allowing some time to be devoted to this work on an ongoing basis.

- Developed administrative support for ongoing effort to bring site-based and part-time faculty to the main campus regularly to work on sharing pedagogy, materials, and assessment approaches.

Appendix C

RPM Quantitative Data Analyses

Project-Wide Data Analyses Using the Student Achievement Initiative Framework

Several years ago the Washington State Board for Community and Technical Colleges (SBCTC) adopted a new performance funding system for community and technical colleges called the Student Achievement Initiative (SAI). The goal of SAI was to improve public accountability by more accurately describing what students achieve from enrolling in Washington two-year colleges each year and to provide incentives through financial rewards to colleges. Through a partnership with the Community College Research Center at Columbia University (http://ccrc.tc.columbia.edu/), the college system has been able to identify key academic benchmarks that students must meet to successfully complete degrees and certificates. These achievement points are meaningful for all students across a variety of sub-categories; rigorous data analysis has identified Achievement points that once accomplished, substantially improve students' chances of completing degrees and certificates. For more information on SAI see http://www.sbctc.ctc.edu/college/e_studentachievement.aspx.

The SAI framework served as the basic data focus for the overall *Student Completion Initiative* referenced in Appendix A, including the RPM project overall, supplemented by more targeted local data analyses specific to individual college projects (described briefly later in this appendix).

While the SAI data provide a useful if generic high-level perspective on student achievement and progress in the participating colleges over the period of the grant, the data analyses provide only limited and uneven evidence of student gains in the core SAI metrics for the RPM colleges. These results were largely unsurprising for several reasons:

1. The available SAI data covers only through year two of implementation for the local projects, which for some colleges was only their first full year of changes in their programs.

2. The achievement points may be too crude to detect gains (e.g., there may be great changes to success rates in early pre-college courses that are not detectable by the SAI metrics).

3. Variation in student goals can skew results (e.g., more students taking certificates not requiring completing pre-college sequence or college math).

4. Research has shown that teacher quality is a significant factor in student achievement. There are large changes in who teaches pre-college courses semester to semester due to variations in tenure track assignment and adjunct mobility.

5. Participating colleges made changes to course sequences, grading policies, and promotion rules that complicate year-to-year comparisons.

6. Cohort effects may influence achievement rates, but there is no control for variations in student quality in the years included in the analysis.

Analyses of pre-college completion rates generally need to address longer time periods in order to account for students moving through the course sequence and into college-level coursework as well as the non-linear paths taken by many students. It is also difficult with these data to differentiate the results of random and known sources of variation from the effects of the interventions (e.g., why did pass rates go up or down 2 percent in a given year?). Further longitudinal analyses will be needed to fully assess changes in student progress and achievement at the project colleges more clearly; it will take additional data collection and analyses for trends to be identified and interpreted.

That said, based on some of the more rigorous and close-grained analyses done at the local colleges accounting for some of the known sources of variation, there are positive signs of progress at some of the colleges (see the "Local Data" section following). Not all of the participating colleges had the resources and capacity to conduct these analyses, but with continued focus on pre-college math in the coming years additional resources and energy will be devoted to conducting such close-grained analyses at more colleges. In addition, SBCTC, in conjunction with key stakeholders from across the Washington community and technical college system, is in the process changing the SAI framework and its metrics, in part to be more effective at tracking students over time. These changes will likely make the SAI framework more useful for assessing efforts like RPM focused on improving the effectiveness of pre-college programs.

Questions analyzed through the SAI framework over the three-year period

1. ***What percentage of students earns a pre-college math point in the year they attempt pre-college math?*** [Note: not limited just to fall cohort]

College Name	2009-2010	2010-2011	2011-2012
Clark*	82%	72%	72%
Everett	71%	69%	67%
Highline	69%	69%	69%
Lower Columbia	67%	70%	73%
Seattle North	70%	71%	71%
Spokane Falls	52%	57%	62%
System Avg.	**71%**	**70%**	**71%**

2. ***For students who start in the fall and begin math in level 1-3 in their first year, what percentage makes substantive gain (two or more points) by the end of the year?*** [Note: Pre-college courses are designated by levels, with level 1 being the lowest—for math, typically titled "arithmetic" or "pre-algebra"—and level 4 the highest, generally "intermediate algebra." Students starting in level 4 would not be able to make "substantive gain," defined as 2 or more pre-college completion points in the year, and thus have a separate analysis—see #3 below.]

College Name	2009-2010	2010-2011	2011-2012
Clark*	40%	33%	38%
Everett	30%	29%	25%
Highline**	27%	12%	15%
Lower Columbia	30%	29%	45%
Seattle North	27%	33%	37%
Spokane Falls***	21%	24%	30%
System Avg.	**28%**	**28%**	**32%**

3. ***For students who start in the fall, and begin math in level 4 that first year, what percentage earns their quant point by the end of the year?*** [Note: The benefit here of using fall is you have one complete year.]

College Name	2009-2010	2010-2011	2011-2012
Clark*	32%	27%	29%
Everett	40%	45%	31%
Highline**	46%	0%	37%
Lower Columbia	56%	47%	48%
Seattle North	43%	45%	49%
Spokane Falls***	10%	39%	31%
System Avg.	**38%**	**40%**	**37%**

**Clark increased grade requirement for a student to be classified "completer," which significantly decreased the pass percentage starting in 2010-2011.*

***Highline reclassified levels, dropping most level 4 classes, so students move from level 3 to college level. This means students who start in level 3 don't have the opportunity to jump two levels, decreasing that number significantly. It also makes the measurement of students starting in level 4 (last chart) irrelevant.*

****Spokane Falls changed the test cutoff scores, and then changed them again, so the levels of students in the classes were not consistent.*

NOTE: Northwest Indian College is not included in these analyses because the college is not formally part of the Washington two-year college system and thus does not report SAI data. We worked with the college to gather comparable data as part of their local data efforts; see the "Local Data" section of this appendix for those results.

Local Data Analyses
(reported by the individual colleges)

Clark College

Clark examined completion rates for two milestones (see table below). Students beginning at a particular level are identified as "Nbegin":

1) The first milestone, indicated as "Nready," is becoming college "ready," meaning the student has successfully completed the pre-college algebra sequence with a "C" grade or better in each course;
2) The second milestone, indicated as "Ncomp," is successful completion of a 5 credit college level math course with a "C" grade or better.

Although the 2010-11 numbers are below average, it is important to note that the later years are expected to have lower rates of completion as these students have had less time to finish their courses. This is particularly true for those entering at the lower levels.

DVED 021*	2005-6	2006-7	2007-8	2008-9	2009-10**	2010-11	Total
Nbegin	344	323	255	342	486	566	2316
Nready	38	46	22	40	37	37	220
Ncomp	24	30	10	20	6	11	101
ready pct.	11.1%	14.2%	8.6%	11.7%	7.6%	6.5%	9.5%
comp pct.	7.0%	9.3%	3.9%	5.9%	1.2%	1.9%	4.4%

DVED 023	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	Total
Nbegin	155	100	110	87	196	226	874
Nready	21	19	17	11	27	21	116
Ncomp	12	14	8	8	7	5	54
ready pct.	13.6%	19.0%	15.5%	12.6%	13.8%	9.3%	13.3%
comp pct.	7.7%	14.0%	7.3%	9.2%	3.8%	2.2%	6.2%

M030	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	Total
Nbegin	761	734	776	874	1084	1161	5390
Nready	243	253	259	257	268	274	1554
Ncomp	150	154	145	138	117	118	822
ready pct.	31.9%	34.8%	33.4%	29.4%	24.7%	23.6%	28.8%
comp pct.	19.7%	21.0%	18.7%	15.8%	10.8%	10.2%	15.3%

M089/90		2005-6	2007-8	2008-9	2009-10	2010-11	Total
Nbegin	711	655	816	1042	1253	1304	5781
Nready	354	339	436	504	579	555	2767
Ncomp	239	227	283	322	290	281	1642
ready pct.	49.8%	51.8%	53.4%	48.4%	46.2%	42.6%	47.9%
comp pct.	33.6%	34.7%	34.7%	30.9%	23.1%	21.6%	28.4%

* Course designation—DVED 021, 023, M030, and M089/90 reflect the most common pre-college math courses taken at Clark.

** Year RPM started (college did not receive direct funding until spring quarter 2010)

Everett Community College

Everett Community College has collected extensive data on a wide range of variables:

a) Conducted algebra skills testing across math classes of students on math problem sets, both created by the department and nationally normed. Results were evaluated by class, measuring average improvement, and were disaggregated in a number of ways, including demographics and by high school.

b) Analyzed the probability of passing Math 99 (intermediate algebra) on first try based on Math 92 (elementary algebra) grade and confirmed that each consecutive higher letter grade (from D to A) in Math 82 substantially increases a student's chance of completing Math 99 on the first try.

General team reflections on local research done on pre-college math courses as part of RPM project:

1) The content and pace of the courses do not seem to significantly affect retention or pass rates in the next course, as long as the course is roughly appropriate for their level. More data might tell a more detailed story.
2) Pre-knowledge of the material to be learned in intermediate algebra is not a predictor of grades in that course.
3) What you teach is what students learn. But…
4) Students who hadn't taken a math class in the past 4 months had much lower stand-alone procedural ability, but NOT conceptual/contextual ability. One possible interpretation is that students lose the procedural skills after a few months, but the conceptual or contextual skills don't fade over time.
5) This skills difference meant that those who had taken the Everett CC intermediate algebra course the previous quarter had much higher algebra skills than the average entry college-level math student. This suggests that multi-term classes like the Carnegie pathways may be more successful because they don't give students time to **forget** the math.
6) This is a bit preliminary, but it looks like a significant majority of the students who started in what was formerly the "basic math" course are going to make it to Beginning Algebra in one quarter (skipping pre-algebra), through the new Math 79 using ALEKS (http://www.aleks.com/). The team speculates that this may be a combination of student attribute-style assignments, the non-linearity of ALEKS (so students can't get stuck on one topic), and the range of the content in ALEKS (arithmetic to college algebra).

Highline Community College

Highline measured pass rates for students in historical, and then redesigned, pre-college classes (Math 81 and Math 91) as well as persistence to college-level. Results show completion improvement for math 91 and substantial persistence improvement for both courses.

Table 1: Historical and Redesign Pass Rate Data

Historical Pass Rate (2.0 or above)		
	Math 81	Math 91
2007-08	0.53	0.48
2008-09	0.63	0.52
2009-10	0.65	0.53
2010-11 (Redesign)	0.67	0.62
2011-12 (Redesign)	0.63	0.67

Table 2: Persistence to college-level data, fall start students

	Persisted to college-level Math (Fall-Winter-Spring)		
	Old Course	New (2010-11 students)	New (2011-12 students)
MATH 081	3 (2%)	53 (18%)	46 (16%)
MATH 091	78 (30%)	196 (40%)	202 (51%)

Lower Columbia Community College

The data LCC collected covered the period of transition to new pre-college curriculum (15-credit/15 module sequence leading to transfer-level courses) and the 5 academic years preceding the transition period (for comparison purposes). The team looked at four basic goal areas addressed below.

1) **Increased success rates (completing a class with a C or above).** Comparing success rates for all pre-college courses there was a 60 percent success rate since transition, compared to 59 percent prior to transition (not statistically significant). The team sees this as a positive. The concern was that there would be a dip in success rates before an increase. The format was new (book/chapters vs. modules) and online homework was instituted (via MyMathLab). The team guessed that it would take a while for students to embrace the changes, but that has not appeared to be the case.

2) **Decreased total credits to complete the pre-college sequence.** The department moved from a 20-credit sequence to a 15-credit sequence, and the hope was that students would spend less time getting "college ready." At this time, there are insufficient data to examine this issue. As the curriculum is relatively new, the majority of students who have completed the sequence in the new system would be those that did not fail/drop/go slower during the sequence, which might skew the average time-to-completion number.

3) **Decreased withdrawal rate in pre-college courses.** Comparing withdrawal rates for all pre-college courses there was a 10 percent withdrawal rate since transition, compared to 13 percent prior to transition (statistically significant). The team felt this had a strong correlation to time-to-completion. They found that students who took a course multiple times would get to the same point in the course and drop, getting no credit for what they knew and getting discouraged with their perceived chances for success. With the new system, which provides various opportunities for remediation, the hope is that this trend of people sticking with their classes will continue.

4) **Increased success rates in students' first transfer level math course.** Comparing success rates for first transfer level math courses there was essentially no change in the initial 70 percent success rate. Also in these courses there was a 8 percent withdrawal rate since transition, compared to 13 percent prior to transition (statistically significant). The sense was that increased time on material and more in-depth focus in the modules, students would retain more and be more successful when they move to transfer-level courses. The department hopes to see success rates improve and maintain the lower withdrawal rates, even with a larger sample of students (though whether fewer withdrawals is a result of students being better prepared is unclear at this point).

North Seattle Community College

North Seattle developed a standard set of math problems that the instructors gave to students at the end of the quarter in all sections (a different test for each level of math) to gauge understanding of key concepts. Over time, the results of this questioning helped them to understand areas of the curriculum that students were not grasping, and also one particular course in the sequence that had more ”knowledge holes” than other sections.

As a result of this work over the past three years, the Seattle North team has created a multiple choice test. This test will be given across the board to all pre-college math students (math 084, 085, 097, 098) and college level (math 107, 141, 142, 146 and 151) during the first week of the quarter. This data will help the team understand what are the most common mistakes the students perform and will show how the department is addressing these topics vertically in the math curriculum.

Northwest Indian College

- Developed method to track completion rates, progress through levels and completion of quantitative reasoning course in a way that allows them to compare their progress to colleges in the SBCTC system of community colleges.
- Designed new placement exam and are testing to see if it more accurately places students.
- Evaluated progress starting at different levels of pre-college math, identifying math 70 (level 2) as the level where most students are lost as they progress toward college math.

Comparison Data for Students Passing Developmental Math with C or Better

Year	Total #enrolled	#passed C or better Passed	%C or better
2009	289	155	54%
2010	317	168	53%
2011	301	158	52%
2012	411	178	43%

Substantive Gain (SG—move 2 or more course "levels" within a year) by Year

Year	Total# Students	#Students with SG	% of SG
2009	34	12	35%
2010	30	9	30%
2011	39	12	31%
2012	55	8	15%

Spokane Falls Community College

Spokane Falls has collected an extensive array of data on their math programs, including:

- Student success/completion.
- Class progression.
- Success in subsequent math and science classes based on prerequisites.

These data are being gathered in a final local report on the progress over the three year period of the RPM grant and will be reported separately and as part of the formal RPM evaluation study.

Appendix D

Daily Core Themes from the Final RPM Institute (Summer 2012)

Structural Redesign (Courses, Programs)

Nationally, multiple structural models (e.g., emporium, acceleration, Pathways) are being touted to varying degrees as the "fix" for developmental mathematics, with a distinct tension between structural solutions and the deep and local work involved in having faculty own and implement new approaches. RPM colleges have embarked on programs to create new courses and/or redesign existing ones, with some variation in the degree to which these new courses reflect substantive change from the traditional sequence versus a reorganization of existing topics. These structural solutions have taken varying degrees of energy and gained varying degrees of traction, depending in part on the college's organizational and departmental context.

Possible sub-areas for focused small-group discussions:
- "Chunking" content/re-sequencing topics
- Placement
- Advising
- Purpose of "developmental math": reproducing high school or preparing students for specific college pathways?

Organizational and Departmental Context

The redesign efforts underway are taking place in the context of complex college structures and dynamics that are not necessarily conducive to comprehensive reforms or supportive of these changes. The most complex and powerful factors appear to be the department level dynamics, including leadership and power/influence issues, extent and nature of department-wide agreements/policies, use of and support for part-time faculty, and departmental decision-making protocols. Broader organizational factors include where the pre-college math program is housed, who is responsible, and whether the college administration is visibly and effectively supportive of innovations in pre-college programs.

Possible sub-areas for focused small-group discussions:
- Ownership of "reform"
- Substance of communication
- Decision-making processes
- Administrative engagement/support

Instructional Practices, Professional Roles

Regardless of the nature of the structural changes underway, one of the major changes taking place through RPM activities is that faculty members are changing their idea of what it means to be a professor. This shift in the understanding of the faculty role appears to be correlated with different levels of involvement in RPM activities. Following the central theory of change of the project, these activities focus largely on faculty efforts to a) "tinker" individually in concrete ways with different classroom practices and strategies around teaching and assessment and b) inquire collectively about the results of those efforts. RPM encouraged common practices (classroom assessments, classroom exchanges, and faculty inquiry groups) to address these areas.

Possible sub-areas for focused small-group discussions:

- Nature of faculty-to-faculty collaboration and co-inquiry
- Focus on professional identity and role
- Changes in classroom practices (emphasis on “tinkering,” micro changes)

Student Perspectives and Behaviors

Despite how it may appear at times, students are not passive “consumers” of pre-college math course/programs; thus it is critical to understand how they perceive mathematics and themselves as math learners and to explore how their attitudes and attributes influence their behavior in pre-college math classes.

Possible sub-areas for focused small-group discussions:

- Focus on what it takes to succeed in math
- Emphasis on value/purpose of math
- Incorporating attributes focus into classroom environment

Developing a Model, Sustaining the Work

Our ultimate goal for the work of the Institute this week is to harness the collective expertise of RPM project participants to develop a “model” for a pre-college math program that builds on what we’ve learned in the project and addresses the tension between a structural solution and a deeper engagement of faculty and students in re-thinking pre-college math. In addition to drafting this collective model, we will hear how colleges will be continuing their work and we’ll explore how to support those efforts collectively with or without new funding.

Faculty Reflections at the RPM Project Final Institute

Note: One of the final activities of the closing RPM Institute, this process asked faculty to reflect on how, if at all, their thinking had changed over the course of the project in each of four different areas: curricular and program structure; departmental culture; instructional practices; and student behaviors/support. The table below represents a sampling of those responses.

STRUCTURE

I used to think...	But now I think...
... but the point is that I didn't. I was shackled to what's already been done, this is how I experience this, this is what the textbook says.	... that I can see structural constraints that had been placed on my thinking: textbooks, tradition, etc., and now I can begin to emancipate myself from them.
... the most important role for an innovator to play was to push pilots & force certain ideas.	... the inclusion of "static" faculty in difficult conversations and valuing their judgment (in real ways) is the most important aspect of structural design.
... students relied on their instructors to learn math & how to be successful college students.	... we must push students out of their "student comfort zone" to become self-reliant, problem solving, hopeful ☺ members of our learning community.
... short daily classes were the only effective teaching method ⟶ students needed to hear my voice daily.	... that students need longer time blocks to deeply investigate topics and ask connecting questions.

CULTURE

I used to think...	But now I think...
... change was just something we talk about, but never actually do.	... given the right conditions and support (monetary, physical, emotional) faculty can actually come together and move forward.
... department, campus & cross campuses collaboration was important.	... it is absolutely vital without a doubt, incredibly important to collaborate within my dept & other departments across the state.
... that all it took to shift departmental culture was one passionate individual and that passion was necessary & sufficient.	... that it takes a team to move & change a large department culture and that a team can (and must) include resistors.
... that my passion for meeting the students needs wasn't shared by many faculty, that they care more about the math than the students. So change was impossible.	... that most of the people involved in teaching care deeply about helping students learn. And that if they knew what to do to change they would do it.

PRACTICE

I used to think...	But now I think...
... there was no hope in changing some "resistant" faculty (from lecturers to facilitators).	... math instructors care about their student's learning. That is the common ground we have to start a conversation about our teaching practices.
... My job as a teacher was to praise students when they did well and explain more clearly when they were confused.	... my job as a teacher is to provide activities and an environment where students can develop their natural reasoning and connect mathematical concepts into a network (not a single line) of ideas.
... that I did a "great" job promoting student sense making. I was good at questioning as a mode to "lead" students to their great discovery – I thought I was good at "knowing" what would lead to student success.	... that I have robbed students, for many years, of discovering sense for themselves...Paying attention to what I observe [with student learning] rather than my belief of what the outcome should be is powerful—I can't go back.

… all math ed reformists had similar views on what is important for dev. math students, specifically a focus on understanding in contextual/conceptual applications.	… the variation in curriculum values among reform faculty is great, but the commonality resides in a focus on student learning and evidence to support future change.
… I needed to perfect materials (class activities, projects for students, etc.) before sharing with other faculty.	… I can share resources (class activities, projects for students) while I'm developing them and I must value & be prepared for criticism that will help me improve those resources.
… it was my job as a teacher to lecture so that students started hearing my voice in their heads, telling them the way to do the problem.	… that students need to develop strategies and skills that are individual that allow them to attack and preserve through problems in a way that makes sense to them.

STUDENTS

I used to think…	**But now I think…**
… student skills and beliefs about math could be developed outside of a context (as in a separate class).	… student math taking skills and beliefs about math can only be changed / developed in context. Meaning they need to be convinced through activities that give them a chance to think about "what it means to do math".
… that the extremely low success rates in precollege math could not be turned around, maybe the problem was too big and started too early.	… there may be enough talented and passionate teachers who can adjust the way they are teaching in a way that will increase student success.
… student attributes were taught outside of a math class (since they can be in a more general sense, not only for math).	…there are mathematics student attributes, hence it makes sense to use time inside a math class to address them.
… there were "smart" students who were "good at math".	… that all students have the ability to be "good" at math, given the proper support, space, and time.

… that group work was a waste of time, that students hated it, and that most people didn't learn. That the "smart students" would do everything, and others would coast.	… that group work fosters an essential sense of community with students which leads to better sense making and learning. When properly facilitated I think it can benefit everyone in profound ways.
…that my teaching career should be aimed at teaching ever-higher levels of mathematics – because I didn't think that I could effectively teach students who dislike or feared math (and I expected to burn out trying). I had the highest respect for those who could motivate and inspire students, but I didn't think that I could do that.	…when I trust in my own ability as an instructor, and expect my student to persist through their frustration without my interruption… students will rise to meet the challenge, and ultimately thank me for being such a pain in the ass (not always, but often enough to drive me to keep giving and growing).

Author Biographies

William S. Moore has been the policy associate for assessment, teaching and learning at the Washington State Board for Community & Technical Colleges since 1990. In recent years he has directed a series of projects focused on improving math achievement and addressing K-12/higher education articulation in Washington including the *Re-Thinking Pre-College Math Project.* Prior to joining the State Board staff in Washington, he taught in a graduate program at the University of Georgia and served as a Student Development Educator at Longwood College in Virginia, helping to create a successful Freshman Seminar program. Over his thirty years in higher education, Dr. Moore's primary areas of work and research have been student and institutional outcomes assessment, organizational change issues, the scholarship of teaching and learning, and student intellectual development. He has a master's degree in counseling psychology from University of Texas at Austin and completed his Ph.D. from the University of Maryland with a concentration in college student development.

Emily Lardner has been co-directing the *Washington Center for Improving the Quality of Undergraduate Education* at The Evergreen State College since 2000. She came to the Washington Center in 1996 as the associate director and helped the Center develop its national reach, combining its focus on equity, math reform, and learning communities. In addition to the *Re-Thinking Pre-College Math Project,* recent work has included leading two action research projects with Center co-director Gillies Malnarich focused on improving student achievement in precollege and gateway courses, *Assessing Learning in Learning Communities and Reaching College Readiness;* collaborating on a three-year *Spreadsheets Across the Curriculum* project; and providing technical assistance and professional development workshops for two- and four-year campuses working on strengthening their pre-college programs and their learning community programs. She serves on the editorial board of *Numeracy*, and teaches part-time at The Evergreen State College.

Gillies Malnarich co-directs the *Washington Center for Improving the Quality of Undergraduate Education* at The Evergreen State College. Since joining the center in 2000, she has helped develop and direct the Center's national and statewide, including the re-thinking of learning communities as a data-based, institutional intervention for student success. Before 2000 she worked with educators and campuses in Canada on policy and system-wide practices related to professional development for faculty and staff, institutional effectiveness, and abilities-based assessment. Throughout her career in both the United States and Canada, including as a teacher in adult literacy and developmental education programs, she has implemented the approach to educating "underprepared" students for higher education she outlines in The pedagogy of possibilities: Developmental education, college-level studies, and learning communities. Currently, Gillies teaches in Evergreen's Evening and Weekend Studies Program.

Michael Davis is a lead research specialist at the Lawrence Hall of Science, University of California at Berkeley. He has taught students of all age groups and from a wide array of racial/ethnic, linguistic, and social backgrounds. Dr. Davis is devoted to helping schools meet the learning needs of all of their students. Because of the role mathematics and science education plays in future education and career opportunities, he has focused his work on these content areas. His research interests include identity, social/emotional functioning, problem solving skills, and how these areas relate to each other and academic achievement. He earned a Ph.D. from Stanford University in educational psychology.