Mathematical Reasoning With Connections:
Development of a conceptually-based fourth year math course

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A. Significance--(1) Magnitude of the Problem

By 2020 up to 65% of all jobs will require some form of post-secondary education (Carevale, Smith & Strohl, 2013). Within Riverside (Riv) and San Bernardino (SB) Counties—collectively known as the Inland Empire (IE) of Southern California—college completion is a critical concern. Two examples from the region highlight the concern, only 19% of San Bernardino County residents have earned a Bachelor's degree (Community Indicators Report, 2014)—making it the least college-educated metropolitan area in the country. Similarly in Riverside County's Coachella Valley region 51% of the adult population is Hispanic and yet only 6% of Hispanics hold a bachelor's degree or higher.

The IE K-12 student population of nearly 1 million is predominately high-need and attend high minority school districts: two thirds of all students receive free and reduced costs lunch (64% Riv; 69.5% SB), one fifth are English Learners (20.9% Riv; 19.2% SB), and far too many dropout between 9th and 12th grade (7.7% Riv; 11.4% SB). Within Riverside County there are 69 traditional public high schools with 32,804 11th grade students currently enrolled; in San Bernardino County there are 57 high schools enrolling 30,093 11th graders.

Table 1: 11th grade ethnicity

	Riv	SB
Hispanic	60.3%	63.3%
Asian/Pacific Isldr	5.9%	5.3%
African American	7.3%	9.0%
White	23.7%	19.9%
2 or more Races	2.0%	1.6%
Other/Missing	0.8%	0.9%

Math achievement is one of the most significant barriers to college completion faced by our students. Based upon 2015 Early Assessment Placement math exams in the 11th grade, **only 6% of students in Riverside County received a score indicating 'college prepared'. In San Bernardino County, 7% were college ready**. The urgency to align the high school math curriculum and instruction with college and career expectations is becoming a crisis for future employability, quality of life, and the regional economy.

On this backdrop, it is no surprise that our local postsecondary institutions are faced with a very costly and difficult challenge related to college-preparedness in math. Of IE high school students that do matriculate, the majority enroll within one of the 11 community colleges or at California State University San Bernardino (90% of CSUSB students are from the IE). CSUSB, which will be contracted to coordinate the team of curriculum development mathematicians, is the sole public, predominately undergraduate four-year institution in the IE, and a minority serving institution (75% underrepresented; 80% first generation to college).

More than half of each year's entering cohort of CSUSB freshman requires remediation in math. Women are disproportionately affected; 63% requiring remediation are Latinas. Similarly, among students enrolled in two of the largest regional community colleges an average of 97.5% test into developmental math. Students who require remediation at matriculation are far less likely to earn their degree. If they do remain enrolled, those students on average take longer to complete their degree than those without the need for remediation (39% vs. 49% graduate within 6 years).

(2) Development of an Innovative Solution. We have developed a cross-sectoral, bi-county collaboration to address the need for a fourth year high school math course that aligns with Common Core State Standards (CCSS). Our team includes key members representing both Riverside and San Bernardino County Offices of Education, numerous school districts, regional community colleges, three California State Universities, and one University of California; they have been working together in a focused manner on this project since October 2015. The lead curriculum development expert on our team was the primary author of the CSU's *Strengthening Mathematics Instruction* curriculum.

This project builds upon work to transform math curriculum across California that aligns

with the CCSS. The math standards are built upon the most important international models for mathematical practice. The math standards provide clarity and specificity, and stress conceptual understanding of key ideas by continually returning to organizing principles (http://www.corestandards.org/Math/). The new curriculum will meet the CCSS for Mathematics Content and the CCSS for Literacy in the Sciences and Technical Subjects. It will follow the Intersegemental Committee of the Academic Senates of the UC, CSU, and CCC model for expectations of entering freshmen for in-depth factual knowledge embedded within a conceptual framework, and for the ability to organize knowledge to ensure the retrieval and application of that knowledge.

The new curriculum for this math course will provide students with a bridge into multiple college and career options, including STEAM, CTE, and non-technical pathways. It will satisfy A-G requirements and will require prerequisites of Integrated Math 3 or Algebra 2. The course being developed is designed to help students gain the necessary numerical fluency and mathematical proficiency to be successful in college math and related subjects which require mathematical understanding. It will address the greatest deficits we see among students enrolled in postsecondary developmental math in this region, and will have the necessary procedural rigor and conceptual depth to ensure that students meet the conditions for college-level math. Long term, the reduction in the delivery of developmental math at the postsecondary level will mean more resources can be deployed within postsecondary institutions to offer more seats in credit-bearing math, and a reduction in the gaps associated with persistence and time to degree.

(3) Addressing the Absolute Priority 2. Course Design & Content aligned with CCSS. Throughout the state teachers are grappling with developing new instructional practices that align with CCSS demands. At the same time, there is a need to deepen teachers' content

knowledge that was acquired prior to the implementation of CCSS. This new 4th year math curriculum is being designed to increase both content knowledge and pedagogical competencies in a way that is transferable to lower level mathematics classes.

The unique and important contribution lies in the innovative pedagogical techniques and teaching guides being developed, which are evidence-based but not commonly found within the K-12 classroom. Modeled upon the Expository Reading and Writing Curriculum (ERWC), which was developed by members of the California State University system, among others, the fourth year math course will enable students who are college-bound to develop habits of mind that include flexibility, transferability, and critical reasoning in their approach to math. Similarly, the pedagogical techniques that teachers will learn will transcend content and level of curriculum, and improve teaching and learning across multiple domains. The curriculum and materials are in modular format to allow for flexible implementation in various settings, including supplementing or replacing existing curricula (see Appendix D for conceptual model of MRWC course). It emphasizes discussion and analysis of alternative representations and multiple perspectives for approaching and understanding content. It is designed to encourage strategic and flexible thinking as well as to enable students to become self-reflective learners. It uses a non-traditional instructional approach emphasizing collaboration and exploration through mathematical games, problem posing, and the like.

The course will seamlessly interweave the CCSS and the Standards of Mathematical Practice throughout the curriculum and empower students to develop the mathematical disposition required for attaining high-level content knowledge. The course problems being designed are substantively different from the problems students have traditionally encountered. Through the careful inclusion of the eight Mathematical Practices, we believe this pedagogical

approach will also address Priority 4 by positively influencing students' perseverance and both teachers' and students' understanding of and approach toward learning strategies.

Topics and problems are being chosen for their intellectual challenge and rigor, to highlight connections between procedural and conceptual knowledge, and to encourage recognition of mathematical opportunities in everyday events. They will require something beyond a single algorithm, such as making connections across topics in mathematics that require creative and divergent thinking. Students will use known procedures to explicate mathematical concepts, as they integrate topics within a single problem as a means to solidify conceptual understandings. Finally, following the lead of Rittle-Johnson and Star (2007) students will engage in discussion of alternative strategies to solving a single problem as a way to enhance the development of flexibility and fluidity with the application of procedures to given problems.

Pilot Testing. Currently, we are conducting the initial pilot test of one module (~4 weeks) of the new course with 19 teachers in 11 high schools throughout the region. The objective for the pilot is to determine the appropriateness of the module content in terms of rigor for students and teachers, and the extent of teacher professional development needed to master the pedagogy. The selection of schools and districts intentionally represents a diversity of performance levels to aid in our understanding of what different teachers and different populations of students will need to successfully engage in the new course.

Table 2: Alpha cohort members & District EAP math performance (2015)

High School (# teachers)	District	% College Ready	% Conditionally Ready
Azusa (1)	Azusa USD	6.7%	16.5%
La Sierra (3)	Alvord USD	2.9%	14.9%
Shadow Hills (1)	Desert Sands USD	7.7%	18.3%
Corona (2)	Corona-Norco USD	8.5%	21.4%
Murrieta Mesa (2)	Murrieta USD	12.6%	24.5%
Chino (1)	Chino Valley USD	15%	24%
Ayala (1)			
Chino Hills (3)			
Cathedral City (2)	Palm Springs USD	4.1%	11.9%

Rialto High (1)	Rialto USD	3%	16%
Summit (1)	Fontana USD	5%	16%

The table below presents examples of the open-ended survey data collected during the week-long professional development workshop. The perceptions of the participating teachers reflected in those comments confirm that they view the curriculum as rigorous, innovative, conceptual, and well-aligned to common core standards and mathematical practices. As of this writing, the Alpha cohort of teachers has just begun delivery of the new content. Data to be collected include observations conducted by the Curriculum Development Team (CDT), teacher & student journaled reflections, final student assessment, and examples of student work. The results will inform the creation of the remaining curriculum and professional development.

Table 3: Alpha Cohort Teachers' feedback about MRWC curriculum and pedagogy

Appropriateness of pedagogy and content

- *Yes. The task-based, student driven learning is excellent for every student group.*
- *We are currently going through a transition and there is a lot of change, high expectations for each student. Therefore we need to be conscious and flexible with our audience and implement the rigor that will help them succeed. We are targeting the right group of students, but they will need a lot of support.*
- *More rigorous in the content in terms of the critical thinking* [than current curriculum]
- *I believe the material is equal in rigor, or slightly higher in rigor. I don't believe the higher rigor comes from the topic, but from the level of inquiry and reasoning required.*
- *The content is engaging and designed to build student mathematical literacy and computational fluency.*
- *It will improve all students' number sense.*

Innovation/Uniqueness and alignment to standards

- *This material is definitely geared more to common core than the courses are currently*
- *My current curriculum is missing all of the interconnected concepts since all topics are isolated from each other. I'm interested to see how my students will respond to this curriculum.*
- *Yes, the MRWC materials sufficiently highlight the interconnected nature of mathematics. The MRWC materials have a different flow than the current curriculum being taught. Also we have never relied heavily on mental math. Nor have we really focused on closure as much.*
- *The MRWC requires students to use multiple SMPs in every activity and class discussion. My current curriculum does not do this.*
- *The MRWC materials definitely help infuse the SMPs into my teaching. I think that our current curriculum allows for some discovery learning and group/collaborative activities, but not as many as the MRWC.*

Professional development and personal growth

- *Definitely. Again, I found terminology that I was misusing and other ways to look at solving that will help my students.*
- *Yes. I have loved the challenge to teach differently and see math and numbers from a different perspective.*
- *Definitely. I just realized I have been saying radicals when I should have been saying roots.*
- *I feel my brain has been stretched out.*

This pilot test is being supported through initial seed funding from the *Southern California Initiative for Education & Prosperity (SCIEP).* SCIEP is focused upon improving educational attainment within our region and aligning with industry needs, and was initially founded through a state award received by CSUSB to form an innovative cross-sectoral, bi-county consortium. The Board is comprised of top educational, governmental, and economic leaders whose support is integral to the success of this project. The pilot project is the first initiative supported by SCIEP, due to the critical role math achievement plays in education and career success. The SCIEP Governing Board will act as the Advisory Board for this project.

B. Quality of the Project Design and Management Plan

Project Implementation Strategy. The i3 supported work will commence in January 2017 with continued development of the new curriculum. The team of mathematicians will conduct a second pilot of the first module with a beta cohort of teachers during Fall 2017. The complete course will be implemented with three cohorts of high school teachers (~60) in Fall 2018. Subsequent cohorts of teachers will be added each year. To support the eventual adoption of the new curriculum and sustainability of on-going professional development (PD), a train-the-trainer model will be employed. As the cadre of teachers grows within schools and districts, a larger network of peer support for on-going PD enabling teacher adoption of the curriculum will occur through MRWC trainer certification.

(1) Goals, Objectives, and Measurable Outcomes. Over the course of the five year project we will accomplish the following goals, objectives, and measurable outcomes.

Table 4: Project, Goals, Objectives and Targets	
Program Goal #1: Increase the number of target Inland Empire high school graduates who test college-ready in math following the completion of the new math course.	
Objective 1a:	*Increase the number of students who successfully participate in MRWC course each year of the grant.*
Expected	By project close, the new course will be delivered in at least 160 high school

Outcome 1a1:	classes to 4800 students.
Expected Outcome 1a2:	75% percent of students from target Inland Empire High Schools who participate in the course will complete the course with a grade of C or better.
<u>Program Goal #2</u>: Improve target students' mathematical performance.	
Objective 2a:	*Increase participating student academic achievement in mathematics.*
Expected Outcome 2a:	Target students who complete the MRWC course will demonstrate an increase in mathematics competency as measured by an end of course achievement assessment designed for MRWC and aligned to the Common Core State Standards.
Objective 2b:	*Increase participating students' eligibility for placement into non-remedial college mathematics courses.*
Expected Outcome 2b:	75% of target students who have earned a C or better in MRWC and who matriculate to a local postsecondary institution in the Fall following high school graduation will place into college level math.
Objective 2c:	*Increase student self-reported learning motivation for mathematics and perceived confidence with advanced mathematical content.*
Expected Outcome 2c*:*	Target students will report significantly higher levels of learning motivation and perceived confidence with advanced mathematics curriculum following completion of the MRWC course.
<u>Program Goal #3</u>: Improve teacher's mathematical pedagogical skills and flexibility by implementing the MRWC project with fidelity.	
Objective 3a:	*Provide professional development for mathematics teachers from target schools.*
Expected Outcome 3a1:	85% of treatment group teachers will attend 100% of the planned professional development and receive a minimum 4 days (one per module) of coaching/observation sessions throughout each school year.
Expected Outcome 3a2:	At least 85% of teachers will be satisfied with the professional development and coaching support provided by the project and its ability to improve their mathematical teaching practices.
Objective 3b	*Conduct annual fidelity monitoring to ensure high fidelity of implementation.*
Expected Outcome 3b1:	At least 85% teachers will deliver at least 75% of MRWC module content with fidelity the first time they teach MRWC, increasing by 5% compliance/fidelity each successive time the course is taught, as measured by teacher survey completed after each module to assess self-perceived competence & fidelity and via a standardized observation rubric.
Objective 3c:	*Increase positive perceptions of MRWC implementation and its impact on student mathematics achievement and learning motivation.*
Expected Outcome 3c1:	Target teachers will report significantly higher perceptions of positive impact of the various components of MRWC on student mathematics achievement following full course delivery.
Expected Outcome 3c2:	Target teachers will report significantly higher levels of student learning engagement with MRWC following full course delivery.
Objective 3d:	*Increase target teachers' perceptions of strengthened pedagogical skills, self-efficacy, and expanded use of the new teaching techniques.*
Expected Outcome 3d1:	Target teachers will report significant increases and improvement in their teaching techniques and math content knowledge.

Expected Outcome 3d2:	Target teachers will report use of the MRWC pedagogical techniques in other courses they teach.
<u>Program Goal #4</u>. Provide professional development to counselors and principals (or other district administrators) to enable greater understanding of nature of the curriculum, goals of the project, and to develop school principals/district administrators as instructional leaders in mathematics.	
Objective 4a:	*Provide professional development and collaboration opportunities on the MRWC to target school counselors, principals and district administrators.*
Expected Outcome 4a1:	At least 75% of principals and counselors from target schools will attend at a professional development meeting on the MRWC course.
Expected Outcome 4a2:	Participating counselors and principals/administrators will demonstrate an understanding of their role in MRWC implementation strategies, the importance of target student enrollment in MRWC, and the intended impact on student achievement.
Objective 4b:	*Increase principal/administrator ability to recognize the standards of mathematical practices and understand how students can engage in mathematical thinking across curriculum.*
Expected Outcome 4b:	By project close, at least 20 principals, who participate in additional MRWC professional development opportunities beyond the initiation meeting will be able to recognize the use of and explain the effectiveness of the standards of mathematical practices and how students can engage in mathematical thinking across curriculum.
<u>Program Goal #5</u>. Using a train-the-trainer model, develop at least 20 teacher leaders who are certified in provision of the MRWC professional development curriculum for on-going support and dissemination to district teachers.	
Objective 5a:	*Develop a MRWC professional development trainer certification workshop to support district adoption and sustainability of on-going implementation of the new course through teacher professional development.*
Expected Outcome 5a1:	At least 20 teacher leaders will attain certification to provide MRWC professional development to district teachers by project end.

<u>Target Students.</u> The target audience for the new course is predominately students from underrepresented groups and low-income backgrounds, which are the characteristics of college freshman most at risk of needing math remediation. The course will develop proficiency, deepen mathematical understanding and mathematical habits of mind (Cuoco et al., 1996), along with metacognitive skills and study skills, and increased math efficacy among students who have completed Algebra 2 or Integrated Mathematics 3 with a minimum passing grade or better. The primary target for this course, and for the rigorous research that is being planned, are those students who are Conditionally Ready according to EAP scores. Long-term, we believe that the

course will benefit a wider audience of students including those who will pursue post-secondary technical majors requiring calculus, and feel the need to strengthen prerequisite skills before matriculation; students pursuing a non-technical major, but wanting to continue their mathematics studies; and students who are Not Yet Ready or Not Ready (EAP), despite having completed Algebra 2 or Math 3.

Teacher Professional Development. Due to the innovative pedagogy, our project includes a strong emphasis on teacher professional development (PD) to support successful adoption of the new pedagogy and curricular content. To achieve implementation with efficacy and ensure the teacher outcomes are achieved, teachers will participate in a rigorous PD that will be delivered over approximately 8-10 days during the final part of the academic year and the early part of each summer. The PD will be focused upon enhancing key math content, understanding of mathematical practices and CCSS, knowledge and beliefs for teaching math, self-efficacy for teaching math (Tschannen-Moran & Hoy 2001), and pedagogical fluency. The teachers will continue to work collaboratively throughout the academic year(s) in a larger professional learning community with postsecondary faculty and teacher leaders through peer-to-peer learning and collaboration. We anticipate that this will also result in dissemination of the pedagogy to lower course levels, and across teachers within math departments.

In order to support the districts' adoption of the course, and to accommodate and support the ever-growing cadre of teachers who will learn and deliver the course each year, we will develop a PD certification program modeled closely on the CSU ERWC model that has allowed for wide dissemination and adoption of the 12th grade English curriculum throughout CA. This entails creation of a train-the-trainer PD curriculum that teacher leaders, math coaches, department chairs and the like participate in to learn how to deliver the MRWC PD, including

on-going academic year support, to other teachers in their schools and districts. This training is led by CSU faculty, and has an annual re-certification requirement. All subsequent PD sessions are delivered in a collaborative manner with a minimum of one CSU or other postsecondary faculty member and the certified K-12 trainers. This allows for better alignment with teacher education standards in the CSU and K-12 needs.

Administrator & Counselor PD. Experience in past school-based projects has shown that the principal's support is key to a school's success of new curricular interventions. We will support principals as "lead learners" at LEA school sites (Liptak, 2005), developing their capacity as instructional leaders in the transition to CCSS. Project leadership will consult with principals and district leaders to develop a model for administrator learning. This could include a site principal joining the professional development sessions throughout a one year cycle; principals attending summer institute sessions; and engaging in professional learning during district-wide principal meetings. Through these activities, principals/administrators will deepen their understanding of CCSS content and practices and the pedagogical implications for effective teaching and learning. This will enable principals/administrators to more effectively monitor, evaluate, and support professional growth in their mathematics teaching staff, and improve their ability to interpret student achievement data on CCSS and other assessment tools that measure college readiness.

Another crucial implementation role is held by high school counselors. The counselors at most high-need schools have a very prominent role in student course placement. To ensure we reach our target students, it will be imperative that the counselors at each experimental site understand the importance of placement of conditionally ready students into MRWC. At a minimum, all principals and counselors will be strongly encouraged to attend an

orientation/project initiation workshop that will provide a project overview, including explanations about the research design, the purpose and content of the course, and the goals of the project. We hope to enhance the counselors' and principals' understanding and knowledge about the math standards, and create the motivation to engage fully in their respective roles in this project.

Enrollment Policies & Procedures. Our final objective is to engage in vigorous policy advocacy across the state of California, with a particular emphasis on the CSU and K-12 systems. We plan to pilot the acceptance of a grade of C or better in MRWC as meeting the requirement for postsecondary enrollment as "college ready" at least one partner community college and CSUSB, and bypassing the math placement tests commonly used to determine the need for remediation. We will also prioritize registration in credit-bearing math course to help ensure that the students continue in math studies to prevent a loss in skills. If we are correct in our belief that this course will prepare students to be successful in college math at matriculation, the evidence we collect from that pilot will be used to advocate for enrollment policy change within those postsecondary systems and for wide adoption of the course.

(2) Management Plan: clearly defined responsibilities, timelines, and milestones. In this section we provide the detail concerning who will be responsible for implementation and management of this project, as well as the detailed year-by-year implementation strategy, with key milestones. First, we introduce the key personnel and their respective roles and responsibilities on this project.

Table 5: MRWC Team member roles & responsibilities

Administrative Leadership	Members & Organizations Represented	Role
PD	Project Director: Mike Barney, Executive Director, RCOE Educational Services	Supervise and support PM to ensure program goals and outcomes are successfully achieved. Provides high-level administrative oversight of i3 grant administration, compliance and fiscal oversight. Communicates objectives, progress, and outcomes of the grant to college/district administrators, consortia and other program stakeholders. Facilitates recruitment of target and control sites. Advocates for adoption of 4th year mathematics.
PM	Project Manager (TBD)	Responsible for day-to-day operation of i3. Consistent, timely communication and feedback to all partners. Compiles and analyzes basic statistical data for reports in accordance with program guidelines. Prepare written reports summarizing results for Advisory Board, Dept. of Ed, and other stakeholders. Maintains records of activities. Manages/monitors the program budget and maintains documentation to ensure fiscal compliance. Secures and maintains contracts from agencies associated with grant. Maintains effective and cooperative relationships with project partners, including evaluator.
SBC	San Bernardino County Liaison/Coordinator: Melanie Janzen, Curriculum Coordinator, Secondary Math	Primary point of contact for recruitment of San Bernardino County high schools. Identification of appropriate sites, collaborate in development of MOU's and data access agreements, communicate with superintendents, principals, and teachers. (Also a member of the curriculum development team)
CDC	Curriculum Development Coordination & Policy Advocacy Lead: Jay Fiene, Dean, Dean College of Education, CSUSB	Provide high-level administrative leadership for coordination of the postsecondary partners. Fiscal oversight of CSUSB contract. Coordinate the on-going bi-monthly CDT meetings. Assist in solicitation of private match. Advocacy for 4th year math, and enrollment policy change.
AB: Advisory Board (Governing Board of the Southern California Initiative for Education & Prosperity)	Kenn Young, Superintendent, Riverside County Office of Education; Ted Alejandre, Superintendent, San Bernardino County Schools; Tomás Morales, President, CSUSB; Jay Fiene, CSUSB; Kim Wilcox, Chancellor, University of California Riverside; Michael Burke, Chancellor, Riverside Community College District; President, Crafton Hills College; Paul Granillo, President, Inland Empire Economic	The Advisory Board is comprised of the leaders of many of the partner institutions on this project. As such, they are individually and collectively able to facilitate the implementation of this project across the region. Provide high-level policy/political support. Advocate for adoption of MRWC. Align and mobilize additional resources for support of this project. Coordinate across their respective organizations to avoid unnecessary competition or duplication of effort. Provide high level advocacy at the state level within their respective systems (cc, CSU, UC, CDE, etc.) for 4th year math.

	Partnership; Sheila Thornton, Vice President, Coachella Valley Economic Partnership	
Curriculum Development	Members & Organizations Represented	Role
CDT: Curriculum Development & Implementation Team	Curriculum Development Lead: Lilian Metlitzky, Professor, Cal Poly Pomona Curriculum Development Co-Lead: Greisy Winicki-Landman, Professor, Cal Poly Pomona	Dr. Metlitzky is one of the leading math teacher educators in the state of CA. Drs. Metlitzky & Landman are the senior math education leaders on this project. Together they will provide guidance to the CDT members about curriculum content, pedagogy, and K-12 educational standards and policy. Dr. Metlitzky will have primary responsibility for the curriculum development, and creation of the professional development and certification programs.
	CDT Members: Laura Wallace, Professor, CSUSB; Josh Chesler, Associate Professor, CSU Long Beach; Ernesto Reyes, Associate Professor, RCC; David Weisbart, Assistant Professor, UCR; Diane Murillo, Math Coach/TOSA, Chino USD; Diana Ceja, Secondary Math Coordinator, RCOE; Anna Kwak, Secondary Math Coach, Azusa USD; Melanie Janzen, SBCSS	The CDT members are all experienced math teacher educators, representing K-12 and postsecondary institutions. Together, under the leadership of Dr. Metlitzky, they will work collaboratively to complete the MRWC curriculum, professional development and certification materials, and deliver the professional development sessions. They will provide on-going coaching and support to the teachers and to the certified trainers. They will conduct the orientation workshops with principals and counselors at EX sites. Work collaboratively with the evaluator on the creation of appropriate data collection and observation instruments.
External Project Evaluator		
EE	Ekaterina Forrester, Key Data Systems	Responsible for research design, instrument development, appropriate assignment to condition and matching, data collection, analysis, and reporting as outlined in evaluation section. Collaborate with the national evaluator.

There are numerous critical tasks and activities that must be coordinated and executed at key points in time for effective implementation of our project plans. We provide detail concerning the implementation strategy, with key milestones and timeline in the chart below.

Table 6: Implementation Timeline & Milestones

Implementation Tasks: Year 1 (2017)	**Key Team Members**	**Timing**
Coordination of regular bi-monthly meetings of CDT. Curriculum development: module 2 & refinement of module 1	CDC, CDT	1/17-5/17
Recruitment of Project Manager	PD	1/17-3/17
Development of data collection instruments & protocol, observation rubrics, etc.	EE, CDT	1/17-5/17
Recruitment of Beta cohort of experimental condition (EX) teachers & control (C) sites/teachers	PD/PM, SBC	4/17
Creation of school MOUs for Principals, Counselors & Teachers detailing counselor's student placement in MRWC, teacher assignment, compliance with evaluation protocol & data sharing/access, roles & responsibilities, etc. *MOUs signed by cohort 1 &2 EX & control sites by 5/17*.	PD, SBC, CDT, EE	4/17
Project induction/initiation workshops with Principals, Counselor & Teachers (separately EX & control sites)	PD/PM, SBC, CDT, EE	5/17
Professional development workshop (module 1: 1 week for Beta EX, joined by Alpha EX for final day)	CDT, EX teachers	6/17
Conditionally ready students identified by counselors and enrolled in course that will contain MRWC module 1	EX site counselors	7-8/17
EX teachers implement module 1 with observation & data collection	EX, CDT, EE	8/17
Coordination of regular bi-monthly meetings of CDT. Curriculum development: module 3 & continued refinement of module 1	CDC, CDT	7/17-12/17
Begin work on development of train-the-trainer certification program for curriculum professional development	CDT	9/17-12/17
Review options & select method/company for professional production of MRWC learning & teaching materials (i.e., teacher manuals, student handouts, math games, etc.)	PD/PM, CDT	9/17-12/17
Quarterly meetings/reporting to Advisory Board	PD/PM	1-12/17
Key Implementation Tasks: Year 2 (2018)	**Key Team Members**	**Timing**
Curriculum development: module 4 *Course complete 5/18*	CDT	1/18-5/18
Recruitment of cohort 3 teachers. School MOUs signed by cohort 3 EX & control sites	PD/PM, SBC	2/18
Project induction/initiation workshops with Principals, Counselors & Teachers (separately EX & control sites)	PD/PM, SBC, CDT, EE	3/18
Evaluation data collection: (1) secure teacher informed consent, (2) train EX & C teachers on in-class data collection/testing, (3) establish baseline data for cohorts 1-3	EE	4/18
Professional development workshop for full course (module 1: cohort 3, 1-2 days per month March-May; modules 2-4: cohorts 1-3, 1 week June; 2 sessions ~ 30 teachers per session)	CDT, EX teachers	3/18-6/18
Conditionally ready students identified by counselors and	EX site counselors	7-8/18

enrolled in MRWC		
Evaluation data collection: secure student/guardian informed consent; pre-test data collection	EE, EX & C teachers, students, etc.	8/18
EX teachers implement complete MRWC course, first half beginning August 2018, with observation, coaching & data collection (both EX and control)	EX, CDT, EE	8/18-12/18
Complete curriculum/materials for the train-the-trainer certification program for curriculum professional development	CDT	9/18
Certify the first cohort (n=5) of MRWC trainers who will assist in future professional development	CDT	11/18
Quarterly meetings/reporting to Advisory Board	PD/PM	1-12/18
Key Implementation Tasks: Year 3 (2019)	**Key Team Members**	**Timing**
EX teachers implement 2nd half MRWC course winter 2019, with observation, coaching & data collection	EX, CDT, EE	1/19-5/19
Develop MOUs with postsecondary institutions for (1) tracking students who matriculate (e.g., college math placement & performance); and (2) to pilot acceptance of passing MRWC for meeting entrance math requirement (i.e., no entrance math test, placement into college level math)	PD/PM, CDC	1/19-5/19
Create Principal PD materials/workshops	CDT	4-8/19
Recruitment of cohort 4 & 5 teachers. School MOUs signed by cohort 4 & 5 EX & control sites	PD/PM, SBC	2/19
Project induction/initiation workshops with Principals, Counselors & Teachers (separately EX & control sites)	PD/PM, SBC, CDT, EE	3/19
Evaluation data collection: (1) secure teacher informed consent, (2) train EX & C teachers on in-class data collection/testing, (3) establish baseline data for cohorts 4-5	EE	4/19
Professional development workshop for full course: 1-2 days per month March-May; 1 week June. 2 PD sessions ~ 30 EX each	CDT, EX teachers	3/19-6/19
Conditionally ready students identified by counselors and enrolled in MRWC	EX site counselors	7-8/19
Evaluation data collection: secure student/guardian informed consent; pre-test data collection	EE, EX & C teachers, students, etc.	8/19
EX teachers implement complete MRWC course, first half beginning August 2019, with observation, coaching & data collection (both EX and control)	EX, CDT, EE	8/19-12/19
Certify/recertify MRWC PD trainers (n=10)	CDT	7/19
Quarterly meetings/reporting to Advisory Board	PD/PM	1-12/19
Attendance at regional and national conferences for advocacy & dissemination	PD/PM, CDC, CDT, EE	1-12/19
Key Implementation Tasks: Year 4 (2020)	**Key Team Members**	**Timing**
EX (4 & 5) teachers implement complete MRWC course, second half beginning winter 2020, with observation, coaching & data collection	EX, CDT, EE	1/20-5/20
Develop MOUs with postsecondary institutions for (1) tracking students; and (2) to pilot acceptance of passing MRWC for 'college ready'	PD/PM, CDC	1/20-5/20
Conduct Principal PD workshops	CDT	4-8/20
Recruitment of cohort 6 & 7 teachers. School MOUs signed by EX & control sites	PD/PM, SBC	2/20

Project induction/initiation workshops with Principals, Counselors & Teachers (separately EX & control sites)	PD/PM, SBC, CDT, EE	3/20
Evaluation data collection: (1) secure teacher informed consent, (2) train EX & C teachers on in-class data collection/testing, (3) establish baseline data for cohorts 6 & 7	EE	4/20
Professional development workshop for full course: 1-2 days per month March-May; 1 week June. 2 PD sessions w/~ 30 EX each	CDT, EX teachers	3/20-6/20
Conditionally ready students identified by counselors and enrolled in MRWC	EX site counselors	7-8/20
Evaluation data collection: secure student/guardian informed consent; pre-test data collection	EE, EX & C teachers, students, etc.	8/20
EX (6&7) teachers implement complete MRWC course, first half beginning August 2020, with observation, coaching & data collection (both EX and control)	EX, CDT, EE	8/20-12/20
Certify/recertify MRWC PD trainers (n=15)	CDT	7/20
Quarterly meetings/reporting to Advisory Board	PD/PM	3, 6, 9, & 12/20
Attendance at regional and national conferences for advocacy & dissemination	PD/PM, CDC, CDT, EE	1-12/20
Key Implementation Tasks: Year 5 (2021)	**Key Team Members**	**Timing**
EX (6&7) teachers implement 2nd half complete MRWC course, with observation, coaching & data collection	EX, CDT, EE	1/21-5/21
Conduct Principal PD workshops	CDT	4-8/21
Recruitment of cohort 6 & 7 teachers. School MOUs signed by EX & control sites	PD/PM, SBC	2/21
Project induction/initiation workshops with Principals, Counselors & Teachers (separately EX & control sites)	PD/PM, SBC, CDT, EE	3/21
Evaluation data collection: (1) secure teacher informed consent, (2) train EX & C teachers on in-class data collection/testing, (3) establish baseline data for cohort 8	EE	4/21
Professional development workshop for full course: 1-2 days per month March-May; 1 week June.	CDT, EX teachers	3/21-6/21
Conditionally ready students identified by counselors and enrolled in MRWC	EX site counselors	7-8/21
Evaluation data collection: secure student/guardian informed consent; pre-test data collection	EE, EX & C teachers, students, etc.	8/21
EX (8) teachers implement complete MRWC course, first half beginning August 2021, with observation, coaching & data collection (both EX and control)	EX, CDT, EE	8/21-12/21
Certify/recertify MRWC PD trainers (n=20)	CDT	7/21
Quarterly meetings/reporting to Advisory Board	PD/PM	1-12/21
Attendance at regional and national conferences for advocacy & dissemination	PD/PM, CDC, CDT, EE	1-12/21
Preparation of summative evaluation and project reports	PD/PM, CDT, EE	6-12/21

(3) Procedures for Feedback & Continuous Improvement. The MRWC project has numerous processes and procedures that it will use for effective and efficient feedback to support

continuous improvement, many of which we are currently employing in our pilot test. (1) We are currently using a web based platform (Edmodo) to connect our development team with teachers piloting module 1. This technology will be used throughout the project as it allows for peer to peer collaboration, problem solving and solution development in real time. (2) Data-driven decision-making is critical to project success. We will utilize data collection and review procedures for all project activities. For example, we used on-line survey data collection for all pilot PD sessions, and are using multiple methods for on-going monitoring and assessment. (3) Administrative management of the project will use of regular, purposeful meetings that include: Bi-monthly (every 2 weeks) curriculum development & implementation meetings; Monthly administrative leadership meetings; and Quarterly Advisory Board meetings. (4) Our leadership and curriculum team members will work in close collaboration with the Project Evaluator. KDS will engage in thorough formative evaluation of the implementation process, and provide regular reports to the project leadership team and district/school staff to enable data-driven decisions about program improvement. At regular intervals, the Project Director, Project Manager, curriculum writers, and the KDS evaluator will meet to discuss the state of the evaluative effort. Modifications will be made as needed to meet the needs of the students, teachers, and administration.

(4) Dissemination Strategies to Support Further Development & Replication.

Specific steps will be taken to support dissemination of information, replication and adoption of the curriculum. RCOE, CSUSB & other project partners, in collaboration with KDS will attend professional meetings and conferences, such as the national or California meetings (e.g., NCTM, SMI, CAPEA). We will be sure to attend a diversity of meetings so that we disseminate not only through education and administrative circles, but also through traditional math venues. Through the philanthropic partners we secure to support this work, we will access their avenues for publicizing this work. Through CSUSB, our leadership team will work with the system level

Chancellors' Office to establish a system-wide group or office modeled after the ERWC. That will allow for meetings to share best practices and work toward statewide MRWC adoption.

KDS will prepare in-depth written and oral presentations of findings at the end of each funded year and upon completion of the grant. Project presentations will be given to share information on the effectiveness of the MRWC course at school districts to stimulate interest in replication/adoption and project. Additionally, KDS will work closely with the leadership team and curriculum leaders to prepare one or more articles for presentation at national conferences, and at least one publication to a peer-reviewed journal at the conclusion of the program. Such publication will add to replication efforts by giving this project wider exposure to a professional and academic/scientific audience.

As mentioned, our team will engage in advocacy across the state of California, with a particular emphasis on the CSU and K-12 systems. Specifically, our team will advocate for the adoption of the new course within postsecondary teacher preparation programs, for four years of math as part of the CSU entrance requirements, and for the course to be offered widely as an elective for high school graduation. In fact, we are already beginning to experience reactions to the pilot that are indicative of the desire of our local districts and schools to adopt this course and support wide dissemination and replication. Members of our team have received numerous inquiries from teachers and administrators within K-12 expressing interest in being part of our project and asking pointed questions about the timeline for roll-out to a larger number of schools. We feel an urgency among our K-12 partners and others to work together to overcome this long-standing problem with math achievement in our region and across the state.

C. Quality of Project Evaluation

The project evaluation will be conducted by Key Data Systems in collaboration with

RCOE, CSUSB, and other project partners. Key Data System (KDS) is a woman-owned small business that conducts educational research, consultation, and systems development, with over 15 years of experience in the field. KDS has extensive experience in conducting project evaluation on various federally and state-funded grants, including evaluating an i3 development grant. All of the state and federal grants KDS has been involved with over the past twelve years have required an extensive needs assessment, data collection, analysis, and detailed reporting. KDS has been contracted by RCOE for numerous research and evaluation projects, and has developed an effective working relationship with top leadership, trust among district and school members, and has extensive knowledge of RCOE procedures and data systems.

(1) Key Evaluation Questions & Methods. The proposed evaluation will be a mixed-methods study with two components: 1) formative assessment of the implementation process, and 2) impact analysis of program effectiveness.

Participants: The primary target population will include approximately 4800 grade 12 students in about 160 high school classrooms. There will be approximately 1200 participants in 40 classrooms in each annual cohort that will receive a full course (2018-19; 2019-20; 2020-21 and 2021-22 cohorts). Control sample will include approximately 4800 grade 12 students from high schools in a neighboring schools or districts that did not participate in MRWC course. Target and control students will be matched on grade 11 CAASPP mathematics scale scores, average grade 11 mathematics grade earned, gender, SES, ethnicity and EL status.

Additionally, teachers from the target classrooms, administrators (principals) and staff (counselors) will be involved in various programmatic and professional development activities. There are various data collection methods planned to evaluate impact on teacher pedagogy, perceptions, administrator and staff knowledge, and related outcomes.

Enrollment: For purposes of the evaluation, all schools enrolled for participation in a given year will be treated as an annual cohort of treatment and control sites. Control sites will become experimental sites the year following their participation as a control. The project external evaluator will work with the RCOE to identify a comparable non-equivalent sample of students from the schools that did not provide the MRWC course to their students matched to MRWC participants on important demographic characteristics to perform a group comparison analysis on the effect of MRWC program.

Data Sources: The methods of evaluation will be aligned with the goals and objectives of the project, including the performance measures, research design, data collection, and analysis. The evaluation will use multiple measures with several sources of data (e.g., CAASPP mathematics scores, grade 11 EAP mathematics assessments, postsecondary math placement & college math course performance, MRWC teacher fidelity surveys, student, teacher and principal perception surveys among the quantitative measures, as well as feedback surveys collected during MRWC PD, standardized observation forms). During year one, the evaluator will work closely with the CDT to develop some specific, critical measurement instruments, which will include: student learning motivation and perceived confidence with advanced mathematics curriculum (Mathematics Motivation and Perceived Competence survey); teacher survey(s) to measure efficacy, curriculum delivery fidelity, and other relevant psychosocial factors; student math competency exam aligned with postsecondary entrance tests, MRWC course content, and common core; principal survey to assess ability to recognize and understand the standards of mathematical practices, and other feedback tools for workshops and training sessions (e.g., counselor workshop, MRWC certification training, PD satisfaction survey items). Finally, the evaluator will have access to the MRWC Edmodo site to monitor collaboration of teachers and

leadership team members, type of communication, and other emergent processes and uses. The platform may also be used as the mechanism for administration of many of the teacher surveys.

#	**Implementation Research Questions**
1	Were the planned number of teachers and principals successfully recruited? What challenges or obstacles to recruitment were encountered and how were they overcome?
2	What proportion of MRWC teachers are participating in all days of MRWC professional development?
3	What proportion of MRWC teachers are satisfied with the professional development and collaboration provided by the project and its ability to improve their mathematical teaching practices?
4	What proportion of study teachers are receiving 4 coaching/observation sessions annually?
5	What proportion of study teachers are implementing the MRWC course with adequate fidelity as measured by MRWC teacher fidelity surveys and observation forms?
6	What proportion of students enrolled in MRWC tested conditionally ready in 11^{th} grade?
7	What proportion of school site principals and counselors attend the project orientation workshops?
#	**Impact Research Questions**
1	What is the impact of MRWC course on students' mathematics performance and college preparedness?
2	What is the impact of MRWC on teachers' mathematical content knowledge and pedagogy?
3	Does the impact of MRWC course program on student performance differ by student subgroups (low SES, EL, ethnicity)?

(2) Rigor of Design & Production of Evidence (WWC). Implementation Fidelity Design & Analysis: The formative phase of the evaluation will assess the fidelity of implementation of the MRWC course, including procedures necessary to ensure effective project management. The MRWC logic model & course content graphic (Appendix D) illustrates the key components of the MRWC project, and the course content as it is intended to be implemented. To monitor and assess the implementation process, the evaluator will attend a sample of planned meetings, professional development sessions, will receive copies of all attendance logs from all planned team meetings, professional development sessions, orientation

sessions, and receive regular (monthly) reports/updates from the Project Director and/or Project Manager and CDT concerning progress on recruitment of school sites, principals, etc., and on their curriculum development activities. All materials generated as part of this project will be available for review by the evaluator.

In Year 1 of the project, most student and teacher outcome data will not be available due to the continued curriculum development and piloting of various MRWC modules. Year 1 annual data collection will therefore focus on the implementation process, including the delivery of module 1 with the alpha and beta cohorts of teachers (e.g., teacher fidelity surveys, student and teacher perception surveys).

The evaluator will review and analyze the implementation data provided from these sources, and compare progress and compliance with plans and timelines, and achievement of the procedural objectives planned for implementation. The evaluator will seek to understand and explain any deviations from plans, and provide regular feedback to the MRWC leadership team to support continuous improvement and implementation effectiveness. The evaluator will prepare a detailed descriptive report concerning the fidelity of implementation and providing a 'road map' of best practices and resource needs for future MRWC replication.

Impact Analysis Research Design and Analysis: A quasi-experimental nonequivalent group design will be utilized as the most rigorous design possible given the constraints of field – based research within a K-12 setting, such as those of equal access. Baseline equivalence analysis will be conducted on the MRWC and control participants to assure that both groups had comparable initial demographic characteristics and mathematics achievement. After matching is completed, all of the matched students will be included in an ordinary least squares (OLS) regression model that will include the same variables as covariates that were used in the

matching process. Ordinary least square regression model will be used to calculate the average difference in mathematical competency (end of year exam) scores and college math course placement and performance between target and control students after controlling for the covariates included in the model to estimate the impact of the MRWC course. Effect sizes will be calculated using Cohen's *d* with the pooled standard deviation. Pre- post-test comparisons of psychosocial factors such as math efficacy, learning motivation, pedagogical competence, understanding of standards of mathematical practice, and the like will be conducted on the experimentation condition students, teachers, principals, using the survey data collected as part of their respective involvement in the project.

All proposed outcomes will be analyzed in Years 2-5 when the full course is delivered. MRWC course impact evaluation will be designed to answer one confirmatory and two exploratory questions. Confirmatory analyses will explore the impact of MRWC on student math performance and college preparedness. Exploratory analysis will examine whether the MRWC course has an impact on teachers' mathematics content knowledge and pedagogical practices. Additional proposed exploratory analyses will explore whether the impact of the MRWC differs for student subgroups. These subgroup analyses will only be conducted if there is an overall effect of the intervention on student performance. Research shows that enrollment in mathematics remedial classes tends to be higher for certain high-needs student groups (minority students, English Learners, students from lower SES backgrounds), so if there is an overall impact of the MRWC on student performance on CSU Math Placement Test, we would be interested in examining if impact of MRWC course program on student performance on CSU Mathematics Placement Test differs by student subgroups (low SES, EL, ethnicity).

Data Access & Storing Procedures: The project external evaluator will establish a data

sharing agreement with RCOE and postsecondary partners to be able to use student records and perform statistical analysis for this project. This agreement assures that access to the data is to be restricted to the project external evaluator and all personal identifying information is to be kept confidential. The project external evaluator will create a project database to track quantitative and qualitative data to be used for project evaluation. The project database will be kept on a safe, password-protected computer. All data files will also be protected by a password. Access to the data will be restricted to project personnel only, consisting of the Senior Evaluator and two Educational Evaluators employed by KDS.

Reporting: As discussed throughout, Key Data Systems (KDS) will prepare formative reports to allow for an examination of which aspects of the project are implemented more or less effectively. An in-depth oral and written presentation of findings will be made at the end of each funded year and upon completion of the grant through a summative report.

(3) Sufficiency of Resources for Evaluation. RCOE sees evaluation as an integral part of the project. An evaluation that is properly designed and executed will contribute to the continuous improvement of the project through on-going feedback, increasing the likelihood of project success. The rigorous design will ensure that this project contributes to the body of knowledge about effective ways to support high need students' mathematical achievement and teacher pedagogical improvement. Production of detailed reports that document the implementation and evidence of impact, as well as describe techniques used to overcome programmatic challenges will be invaluable for other LEA's and postsecondary institutions faced with similar challenges, as they seek to replicate the work of this project. These are critical goals of this project, and we will ensure KDS has access to the material and budgetary resources needed to conduct this evaluation with the highest level of integrity.