

MATHEMATICAL REASONING WITH CONNECTIONS

Quantitative and Qualitative Data

MRWC is a fourth-year high school mathematics course designed to prepare students for the expectations and rigor of college mathematics courses. It reinforces and builds on mathematical topics and skills developed in Integrated 1-3 (or Algebra 1-2 and Geometry) and is designed as a bridge to college mathematics courses required in either STEM and non-STEM majors. It is accepted as an advanced mathematics course by the University of California and California State University systems.

PARTICIPANT NUMBERS – 2017 – 2022

Students: 12,265

Teachers and Coaches: 166

Schools: 78

Districts: 24

WHAT THE DATA ARE SAYING

- MRWC and control students (Other senior-level courses such as PreCalc, PreCalc Honors, AP Statistics, Integrated Math 4) were given pre/post Mathematics Perception surveys and an end-of-year Precalculus Concept assessment.
 - MRWC students have outperformed Control students on the end-of-year assessment in 2018, 2019, 2021, and 2022 (no assessment was given in 2020 due to COVID-19 school closures).
 - Data from the pre-post mathematics perception surveys indicated that MRWC students are increasing their attitude towards math, the usefulness of math, and their desire to take math in the future while control students are either decreasing or remaining relatively flat.
 - With questions where Control students did increase, a greater increase was seen with MRWC students. For example, when asked if students would like to take more Math courses in the future, MRWC students who agree/strongly agreed increased by 16.8 percentage points, while Control students increased by 9.1 percentage points in 2020.
- Compared to control courses, MRWC course served significantly more Hispanic students (MRWC: 62.1% vs Control: 56%) and females (MRWC: 59.1% vs Control: 52.8%), two student groups historically underrepresented in STEM education and careers. Even more importantly, MRWC females and Hispanic significantly outperformed students in other advanced mathematics courses on the measure that assesses students' preparedness for college-level calculus.
- Additional data were collected on post-secondary enrollment and success of the MRWC and control students, who participated in our project. Both MRWC and control students were followed into CA post-secondary community colleges, where the majority of Inland Empire students attend. Preliminary analysis indicates that for the cohort analyzed, MRWC students passed STEM courses with a C or better, at a significantly higher rate than Control Students (60.10% vs. 55.70%).

WHAT THE STUDENTS ARE SAYING

Students told project staff the MRWC course has helped them be more confident in asking questions in class, be more open to different ideas, be able to explain the why of mathematics better, persist when roadblocks arise, and feel challenged in a good way. Below is a sample of what we heard from MRWC students during end-of-year interviews.

Abolish the phrase “I am not a math person” and Shifting Student Mindsets

- *Like, I took honors math classes in previous years. And like it was just one way. And if you didn't do it that way, then it's wrong. And I just felt like, stupid, because I could never like, figure out why. But now I kind of can. I don't feel as dumb.”*
- *...I've always disliked math [for as long as] I've been in school, but since I've been in the class [MRWC], I've actually grown to like math a lot more. It's nowhere near like any other math classes I've ever taken. It's way different. I actually enjoyed math and I'm actually wanting to get to class to learn. And it's not like bland and dull like other classes, where it's just you've learned it and you just recite it back to the teacher on a test, but this like actually helps me.*
- *I think this is one of the best math classes somebody could take, if you don't already like math.*
- *To be honest, before I came in to MRWC, I hated math. It was always like my worst subject, I always ended up like with C minuses in the class, no matter how many times I came in for tutoring and all that kind of, all that resources that I've reached out to. It really just never worked out. And after MRWC...I feel that math is one of my favorite, favorite subjects now.*
- *I actually used to really, really hate math and try avoiding it whenever I could but with this class it's like I understand it more and I don't hate it, but I don't hate math anymore.*
- *One thing that surprised me is actually gain help from your team members. Because, like I said I came into this class, with negative mindset, oh, I'm not going to do nothing. But once I started to work with a teammate or the teammates I had, I said, wait they're actually helping me understand what I'm doing and actually guiding me what we should be thinking together.*
- *I think that every math class should be like this. I feel like a lot of people, well like I did, we looked at math negatively. It's very boring or very just straightforward, you just regurgitate what teachers have taught you like equations and things like that, but in this class that's completely changed. Math is more, you think outside the box more. It's helped me communicate with students, it gets me to interact with my teachers more and just other ways of thinking, so I think that every math class should be like this.*
- *...I've always disliked math for entirety I've been in school, but since I've been in the class [MRWC], I've actually grown to like math a lot more. It's nowhere near like any other math classes I've ever taken. It's way different. I actually enjoyed math and I'm actually wanting to get to class to learn. And it's not like bland and dull like other classes, where it's just you've learned it and you just recite it back to the teacher on a test, but this like actually helps me.*
- *So before I could say, I didn't really like my math, I liked it but it wasn't like something that I was excited to be in. MRWC it felt like it was, it was my first period class and I would wake up and I already knew I was going to math and I actually was enthusiastic to go because I knew I was learning something new and I was able to go up in front of the class and show other students my work and get feedback from them.*
- *I have never liked math. It has never been one of my favorite subjects. But after taking the MRWC course, it completely changed my thought process. Just because I feel like no matter what math I go into now in college, I'll be able to excel at it more than before. Because I always had such a negative way of thinking towards math because I was just*

like, I can't get this. I don't understand it. But after learning how to break down individual problems, I believe that I'll be able to succeed much more.

- *So high school is what kind of ruined math to me. But if I'm being like, completely honest, this year was probably like my best math that I had. And I can say that with like, total, like, no filters, no, nothing applied. Like, I really, really liked this course.*
- *I feel as though it helped me appreciate math more.*
- *I didn't really like math at all when I first started this class. I like math a lot more than when I first started the class. I would definitely recommend it to other people, especially the people don't like math. They would definitely like this class. It's different. It's more interactive it's completely different from other classes that just showed like a very boring aspect of math. MRWC is a class where it shows you more interactive and just a better way of teaching math.*
- *I definitely feel more confident after taking this class to be prepared for what's coming in college.*
- *Sometimes, I used to feel like if I didn't understand the problem, I was like, wait, I don't have to do this. I don't understand. But as soon as I figured out why we had to do it that way. I actually started understanding. It was like, the floodgates open, it was like, Oh, that's why. Okay. And I would just immediately get it.*
- *It's like the glue, all our classes are like the pieces, and this is like the glue.*
- *I definitely have more confidence going towards math problems like I'll see a certain math problem and I'll just have to think about it for a bit, but I'll definitely know how to solve it because of this class. With all the skills that we learned throughout the year, just working on math in general, it's just easy, it got pretty easy.*

Transfer of Skills Learned

- *There is more appreciation of my education in my other classes. I feel like kind of I can do anything. I show up to show up. But here I am always working. And I'm pretty diligent in that aspect. Like, I do want to be a good student. And I do want to work hard. But in here I actually get that opportunity to do so because the foundation of MRWC is behind the purpose. You need to pay attention.*
- *This class helped me a lot with SATs, and I'm gonna be honest, I was like looking at problems, I was like, Oh, MRWC, but I did in a different way and I got the answer. And like if I was in algebra two, last year, I took my SATs, I had no idea what I was doing. So, it's like a deeper meaning and deeper understanding of what you're asking now.*
- *When I am helping someone, like a junior, she's in Algebra II, I'd be like, Oh, yah, they find the answer first, like, and then tell them why and they say, why are you telling me this, and I say MRWC THAT'S WHY!*
- *I feel like at the beginning of the year, I would have said no, don't do this class, because I didn't understand it. Like now I'm like, yeah, you should, because like, it helps a lot with other stuff, too.*
- *And it's [MRWC] just going to help me. Like if I get stuck somewhere like at least I know there's other ways to go, rather than just stop. I can now like dissect the problem, find different ways around it and come back to you.*
- *I think something just like really discussing through problems like even it just helped kind of like my communication skills in my other classes. Like just knowing how to explain my thought process, instead of like kind of getting stuck and not really being able to explain it. Like in government and econ we're doing this big project, so I was able to like explain my way through it and just find like different ways like just telling them, like, oh yeah, this is my process of how I found out like this whole thing.*

- *So honestly, the whole math portion isn't completely applied to what I have to do. But I just feel either way, I still feel more prepared, because this class has told me that I should not be afraid to ask questions, because that's something I've always struggled with not just in math. But starting this class. It was like, every single time I knew I had a question I asked, and that helped me out during the year as well, because I would use in English and psychology and all of these courses.*
- *now I'm like Okay, I can look at this and I can take the things I know, and even if it's wrong it's Okay, but I can take the things I've already learned in try using it on this and I didn't ever used to do that, and I feel like I'm able to do that now.*

Increased Communication Skills and Community Building

- *In my opinion MRWC was very conversation based and discussion based...I'm not really a pen and paper kind of person. I don't like the formulas and just trying to get answers, one answer one certain way. Just like the groups communicating with each other and being able to find one answer six different ways. It was just a lot more exciting and a lot more, easy to follow and it wasn't just do it on your own. It was like if I needed help anyone could help direct me to the same answer.*
- *In this class you're more like, you ask a question and everyone will be like, yah, yah. In other classes they were just like, be silent, and basically just suffer because they didn't know like what to do.*
- *I think the communication is really key in this class. Because like, at first like in a regular class, they say partner up with a buddy next to you and share your answers. And it's like, oh, here's the answer, I hope you have the same thing. But like here. Like we're talking like math vocabulary, which I've never done, and we're debating like why is this correct or why is that way correct. And like, I think that's the one thing you're asked to like, in this class, communication skills, being able to talk to others you haven't talked to before.*
- *I would probably describe it [MRWC] as a new way of doing math...It's a discussion based. It's helping to open your mind. It is a classroom with such a positive energy, because it's not just a quiet classroom where everyone is doing their own thing. It's very inviting, very accepting of everybody's answers and ways of thinking. It's just an overall great experience of a math class. Definitely better than my previous three years of math.*
- *I feel like it [MRWC] did help me with persistence and communicating because math usually a lot of people think they won't need it in the future, but at the end when you're learning it and you start seeing and viewing everything you know that you're going to need it in the future.*
- *I usually work on math just on my own. I didn't really like working with other people, I thought it would make things more challenging. I was completely wrong; it really did help my communication skills with other people and just communicating math and math ideas and different routes of thinking towards the same problem and yeah it did really help me with working with others to solve that issue.*
- *There was a lot of communication and collaboration and teamwork...[MRWC]makes you really think together instead of thinking like by yourself like a more traditional class would.*
- *The way I learn I have to teach myself. The fact that I could understand it and then I was comfortable enough to teach other people, that was really, um, this is hard for me, I need a word for it? Rewarding? Empowering.*
- *I'm not a very social person I'll say I'll just work by myself, whatever and I know that's not what the class is about it was supposed to help, you were supposed to work together and I started making a lot more friends Now I know a whole bunch of people in the class, and we ask each other questions and talk all the time, not even just about math, about*

music or our lives and things like that, so I feel like I've gotten better with communication because of it or communication and collaboration those things. I think it really helped me to like open up a little bit and share what I know.

Improves Critical Thinking and Problem-Solving Skills

- *And but there's also other thinkers, like C was saying that where she needs to know like a different way. And you that might motivate her so now [in MRWC] it's not wrong, wrong wrong. And let's say we don't know something you can actually create something new, you know, by giving her the opportunity to try something different. Find the same answer in a different way.*
- *Since it is not as straight forward and there are a lot of hoops to jump through and stuff, like it makes you use your head more*
- *Classes before this, we just learned how to do it, like just the formula and figure out the answer and we're good. And on this side, it was more like understanding the meaning behind it and do it, and I like that*
- *It's like the glue, all our classes are like the pieces, and this is like the glue.*
- *I really liked the balance between the work and the discussions...If I ever had a question, I was never afraid to raise my hand or to just ask someone on the side it was just such an inviting space. And I really enjoyed it a lot more than my other classes.*
- *I think it is very beneficial if you recognize that you can divert from traditional ways of learning or teaching math. There's different ways to approach it. And it's scary when you think there's only one way you don't understand it, you lose hope as a student, not only in math but in other subjects. So, I think it can really help build a stronger class of students, so that when you get into the real world, are not afraid to fail in any aspect.*
- *From what we did, a lot of students had different answers and alternative routes of thinking and also just it, it made me think more so, what the problems were, and it made me look at math differently, because I realized that there was more than one way of looking at the problems and also it just made me think I had never, I never would have guessed, like the other routes they took to solve the equation. So, it definitely made me think more.*
- *... It's just like my mind got used to like finding different ways of solving the problem, so when I look at a problem, and I saw like the traditional way I'm like, I could solve this a different way and it could be faster, so I like that I'm able to find multiple ways to solve a certain problem.*
- *I feel like the equation looked very complicated and before, I would be like, oh, I don't want to do this problem, looks too complicated. But this class helped me, like dissect everything I knew to get the right answer.*
- *I think in this class you get a feeling of comradery I guess, where in other classes it's like just individual work, just sitting there listening to a teacher. In this class you talk, you're getting together and getting to know the other students in the classroom working together to solve problems.*
- *It definitely felt like that it's not like the teacher just held our hands through the entire process, we were able to learn and figure out the problems ourselves.*
- *That's another thing like it [MRWC] really let you like open up your creative side because when we do our class discussions, she let anybody talk. And then we just realized like, how all the students did it in different ways and even she was learning with us through the process. So, it's just like your own thoughts help you push through the problem, and you can see it in a whole new way.*

WHAT THE TEACHERS ARE SAYING

Teachers articulated that the MRWC professional learning had an impact on their teaching. They discussed how it helped change instructional practices in their MRWC and other classes,

deepened their own conceptual understanding of the higher-level mathematical concepts, and provided a professional learning community. Below is a sample of what we heard from teachers from professional learning reflections and evaluations.

Shifting Mindsets and Pedagogy

- *My method of teaching improved allowing me the opportunity to have my students become more independent and self-sufficient in the learning process.*
- *The professional development has definitely helped. I can also see how it has helped my students solidify their learning. When I listen to their conversations I am convinced that it's a great course.*
- *I was more willing to invest the time and energy into creating hands-on experiences and problem-solving strategies.*
- *I really liked how the concept of closure was presented. I never pictured being able to bring concepts like these into a high school environment.*
- *The conversations that happen among my team, among the cohort, and with professors have pushed me to be better.*
- *I will have to say that at the start I did not want to implement a new curriculum at our school site. However, now that I am done with the first semester and starting the new semester, I will have to say that I love this class. Can't wait for next year to start.*
- *Teaching MRWC has significantly improved my teaching in other math classes in both content and lesson planning for student engagement.*
- *The conversations that happen among my team, among the cohort, and with professors have pushed me to be better.*
- *I believe this is how math should be taught.*
- *I loved thinking about the math in a different way.*
- *I really like the idea of giving students the opportunity to find their own pathway to a solution. This idea is so powerful for students and really provides an opportunity to build confidence within students.*
- *My method of teaching improved allowing me the opportunity to have my students become more independent and self-sufficient in the learning process. This has made them look for the connections to previously taught and learned material.*
- *MRWC has impacted me, through its content and the pedagogical approach that it entails, to make more aggressive steps to becoming the facilitator of mathematical discussions rather than the deliverer of mathematical understanding. Moreover, there is now a higher level of awareness and consciousness on the emphasis on clarity and precision of the language of math and key points to surface.*
- *My teaching methods in my Calculus and Math 4 are evolving much more this year comparing the past years. Because I see the benefits in students learning through explorations, collaborations, and reasoning, I started to implement many of the methods that I am learning from MRWC training sections.*
- *Allowed me to open the students up to more discussion and team-based learning*
- *It improved my mathematical language and gave me a better perspective which I was able to relay to students.*
- *Thank you very much for the best PD I have ever had! Some of the other PD's I've been to have been a lot more lecture-like, but you all have worked hard to ensure that we spend the vast majority of our time working, engaging with each other, and devising how we might implement the curriculum within our own classes. Again, thank you very, very much!*
- *I will have to say that at the start I did not want to implement a new curriculum at our school site. However, now that I am done with the first semester and starting the new semester, I will have to say that I love this class. Can't wait for next year to start.*

- *I think that MRWC is a class that needs to be taught in order for our students to be successful in college. Teachers do not realize how much our students are not really grasping. Throughout the days that I have been teaching, I think that this is a great class to better prepare our students.*
- *After doing several activities, I'm understanding that the class goals are not just to complete tasks but to be able to communicate and have a deeper understanding of the connections.*

Community

- *I loved it. The math we got to talk about, the resources, the community, it was all amazing.*
- *Support from the MWRW community in the training and beyond is so helpful! I think the networking that has happened from this time is so valuable!!*
- *I had a great group for collaboration at the beginning and it really makes a difference. It showed me why creating that community at the beginning of the school year is so important.*
- *I would have to say the bond I now have with my district cohort [was most helpful]. We have been able to work together and implement everything we talked about.*
- *The most helpful aspect of today's training was the ability to make connections with other educators and sharing how we can strategize to help students improve understanding of mathematical concepts.*
- *I always learn so much from my colleagues.*
- *I loved being able to talk with colleagues about the implications of this kind of thinking and how it would change how students think when they reach the university level.*

20 Days of Professional Learning (Over 2 School Years)

- *I will say that I would like more days of training.*
- *I couldn't understand how I needed 20 days since it's just math, but wow was it needed!*
- *My first reaction was complete shock over the 20 days of training and I definitely had no intention of jumping on board. Fortunately, I attended Day 1 of PD. My colleague and I agreed to attend the first day and then decide if MRWC was worth a 20-day commitment. It was that 1st day of PD that really sold us on bringing this curriculum to our kids! I am extremely thankful that I did not pass on this opportunity!*
- *...I did not imagine that the 20 days of training would be so in depth and useful. I am thoroughly impressed at the amount of details that went into each training and all the presenters that helped communicate the content and engage us during these trainings. Going through these trainings actually made me happier to teach the class. I always feel revitalized after the trainings and happy to get back in the classroom and share.*
- *I love how all the presenters allow us to dialogue, share our perspectives, and generally discover, fail, and reshape our understanding through the process.*
- *By doing the activities we are already anticipating our students' solutions to the task. Manny and Scott then demonstrated how we should monitor our students, select work to discuss, sequence them in an appropriate manner, and make connections. By participating in this training, we are experiencing exactly how to incorporate the 5 Practices into our teaching.*
- *All of the instructors demonstrate exactly how we should be incorporating the 5 Practices into our teaching by having us anticipate what our students will do by doing the activities ourselves, monitoring what we are doing, selecting and sequencing our work, and following up by having discussions with us so that we can make connections."*

- *Thank you very much for the best PD I have ever had! Some of the other PD's I've been too have been a lot more lecture-like, but you all have worked hard to ensure that we spend the vast majority of our time working, engaging with each other, and devising how we might implement the curriculum within our own classes.*
- *Thank you for everything and for constantly changing up the sessions or the modes of learning. It made the two weeks a lot better than they could have been if we ONLY did one mode of learning. It was a great example of what my classroom should look like*
- *Thank you all for this training. Every time I attend, I feel inspired to be a better MATH teacher. THANK YOU!*

Transfer of Knowledge to Other Courses

- *Teaching MRWC has significantly improved my teaching in other math classes in both content and lesson planning for student engagement.*
- *It made me focus more on the connections between different concepts. I see this helping me being more effective teaching Integrated 3 next year.*
- *My method of teaching improved allowing me the opportunity to have my students become more independent and self-sufficient in the learning process.*
- *I feel that MRWC helped me concentrate on specific areas in IM3 that I would normally not spend as much instruction time with my students. I also focused on MRWC topics in my Precalculus classes.*
- *It definitely got me to focus a bit more on conversations of math even though the other classes I teach are quite different. It would be fun to take some of the activities and use them on particular days to focus on communication abilities for all of my students in other classes (pre-calculus, AP Statistics, Probability, and Statistics).*
- *Over 20 days of professional development for MRWC, I learned how to implement the 5 Practices for Orchestrating Productive Mathematical Discourse and how to encourage students to engage in the 8 Standards for Mathematical Practice. Whereas I had been trained in each of these previously, the extended, repeated nature of these trainings really helped me develop a deeper understanding of these concepts and how to implement them effectively in my MRWC class. Using what I learned from these MRWC professional learning trainings, I was also able to develop lessons for my other class (Integrated Math 1) that were specifically designed to get students engaging in mathematical discourse and participating in the standards for mathematical practice.*
- *I have a better conceptual understanding which can be transferred to other classes.*
- *All strategies and practices can be transferred into all other math courses.*
- *The SMPs apply to all math classes. Students benefit from learning socially and working together regardless of the course.*
- *All math classes can certainly benefit from activities such as today's. The freedom for students to test/check their thinking is great!*
- *Discussion like this could be powerful in other courses as well.*

MRWC Strategies

- *It is impossible to not incorporate the SMPs [Standards for Mathematical Practices] into your teaching if you are properly using the MRWC curriculum. We are constantly using multiple SMPs in every activity and class discussion.*
- *MRWC has made me more cognizant of the use of the SMPs in all of my classes. I also try to make sure that my students and myself are using the appropriate mathematical language.*
- *All of the instructors demonstrate exactly how we should be incorporating the 5 Practices into our teaching by having us anticipate what our students will do by doing the activities ourselves, monitoring what we are doing, selecting and sequencing our*

work, and following up by having discussions with us so that we can make connections.

- I'd like to mention that the self-teaching or you allow the students to collaborate with each other and not really like force them to work with the teacher, but have the teacher help them when they need it. It's a nice style of teaching that encourages the student's growth and, like having them figure out the problem themselves.*
- The problems lend themselves to persevering and questioning student thinking about math. These lessons also allow students to model mathematics in a way that it can make sense.*
- I continue to like the creation of student discourse to make meaning of content. The communal nature of making sense is awesome.*
- One of the activities have the students use multiple SMPs, so it will be easy to incorporate them into my teaching. Thank you!!!*
- The training shows us exactly how to incorporate the 5 Practices into our teaching, since we are doing the activities as students and anticipating what they will do, we are seeing the presenters monitor us, and we are discussing how we would select and sequence the student work to make connections.*
- This course has really pushed me to connect the different math concepts and deliver it in a way for students to make those connections on their own without me having to guide them so much! I am trying to do this in other classes as well!*
- Great to be back doing math all day! Sad that we only have two more to go. Every time I attend, I get inspired to be a better teacher. I'm not teaching MRWC now and I'm with mostly 9th graders all day, but we are doing the Open Up Resources curriculum which lends itself to the 5 practices and this training really helps me build my confidence/ability to create a classroom where students are thinking.*
- All of the presentations modeled how we could teach the concepts and use the activities in our own classrooms, so we were able to see how the activities made students persevere, attend to precision, construct viable arguments, use appropriate tools, and make use of structure.*
- One great thing about MRWC is the fact that as long as the teacher follows the curriculum, it is a given that the 5 Practices are automatically embedded in the activities.*

WHAT POSTSECONDARY FACULTY ARE SAYING

- Succeeding at college-level mathematics requires identifying the essential interconnectedness of mathematical concepts. MRWC not only emphasizes these connections, it supports the development of critical thinking tools which allow students to exploit these connections to grasp new concepts. It is exactly the kind of class I wish my undergraduates had the opportunity to take in high school. – Scott Cramer, Mathematics Department, California State University, San Bernardino.*
- MRWC provides students with so many of the skills and thought processes that are ideal in a student studying mathematics. I wish I had a chance to experience this class in high school! It really connects so many ideas of mathematics that they have been studying for so long and provides students opportunities to experience productive struggle and mathematical discourse in the classroom. – Elizabeth Cannis, Mathematics Department, Chaffey College.*
- MRWC is an important class that pushes students towards the heart of mathematics. We must remember that the underlying skill that unities the various branches of mathematics is critical and abstract thinking. Indeed, a mathematics course is not simply a list of topics to be crossed off one at a time. MRWC trains students to be problem solvers with well-designed activities that promotes mathematical maturity. It provides students with a*

solid foundation that can easily be built upon in college. The most important piece of evidence that indicates that MRWC gets it right is this: many of our high school teachers have told me that, as they teach this course, they are reminded of the joy and excitement they felt as math majors. And joy is the heart of mathematics. – Michael Sill, Associate Professor of Mathematics, California Baptist University.

- *As a community college professor, I have seen first-hand the push to have students learn mathematics in a collaborative and engaging classroom setting. MRWC teaches students to discover mathematical concepts through low-stakes activities done in collaborative group settings. It takes away the fear and anxiety often associated with math by treating mistakes as opportunities to learn, allowing for discussion, and celebrating discovery. Students learn to be independent thinkers, innovators, and team players. These are skills that will prepare students for success in their postsecondary education. Students will greatly benefit from the experience of learning in a MRWC classroom. – Michelle Black, Mathematics Department, Riverside City College.*