White Paper
K-4 Mathematics Academy

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Introduction

STEM+ is aligned with the mission, vision, and core values that frame the New Mexico PED Comprehensive Strategic Plan, as it too offers pathways to transforming teaching and learning in core subject areas by promoting social emotional growth, 21st century skills, and college and career exploration and readiness for all students in New Mexico. By focusing on quality evidence-based instructional best practices, together we can affect positively student STEM outcomes.

Students today live in a world that is a click away, and to succeed they need to become more comfortable and confident with mathematics and computational thinking. STEM+ offers a track to develop these skills for solving problems across content domains in the environs of community schools. The two main components of STEM+ are to increase student achievement and confidence in mathematics and grow the exploration of college and technical career opportunities.

K-4 Mathematics Academy

The STEM+ mathematics component for K-4 students draws on multiple content domains with a specific focus on mathematics, computational, and language literacies. They form the foundation of the Academy's project design, that begins where the students are and support them developmentally, linguistically, and culturally to meet their academic, social, and emotional needs. Its overarching goal is to build STEM knowledge and skills that are fundamental to problem solving and analytical thinking essential for students' future success.

The goal of the Mathematics Academy is to improve proficiency in mathematics. To reach this goal of improved proficiency in mathematics, computational, and language literacies will require intentionally integrating them across grades K-4. Students learn to think algorithmically as they read math texts, break down the information and work with one element at a time, determining what is important to work out solutions.

Such thinking empowers our students with confidence, tenacity, and a general curiosity across multiple content domains. Developing critical thinking encourages students to make connections and find new ideas between these areas of study and equips them with "a rich toolkit to draw from that crosses traditional subject borders" (Sheldon, 2017). In the Academy design, these literacies are front and center along with high-quality professional development, teacher coaching, and targeted ongoing classroom tutoring.

The sociocultural conceptual framework underlying the Academy's integrative literacy approach demonstrates how core areas of the curriculum are intertwined. An explanatory methodology will be used to address the question: In what ways and to what degree did participants in the Academy implement the mathematics, computational thinking (CT), and language in their classroom instruction? The focus will be on the co-development of math, CT, and language.

Participants will attend monthly PLC meeting to bring participants together and share ways that they have used the literacy approach and the embedded strategies with their students. Quantitative district and campus measures will be analyzed along with qualitative data from teaching episodes, classroom observations, and student math talk four squares and other individual and class writing samples (Gerrard, 2013). These data will offer insight into students' mathematical thinking and reasoning, as a result of implementing best practices, demonstrating that mathematics is more than learning numbers; it is about language and the decomposition, pattern recognition, abstraction, and algorithms--the cornerstones of computational thinking. Where possible the data will be compared with those teachers and students who did not participate in the STEM + K-4 Academy.

Intentionally embedding mathematics, CT, and language in the program design offers a context and platform for making math learning more relatable and approachable. By doing so, it generates student excitement, which is an important first step to gaining confidence followed by understanding and comprehension. By emphasizing the communicative skills as expressed through language, students move beyond squeezing numbers from their heads to their hands to their pencils to their papers until they get the answers, as Carl Sandburg wrote in his poem "Arithmetic."

Mathematics coupled with language and CT form a necessary and unlikely partnership that can strengthen students' understanding and contribute to meaningful and purposeful math talks and discussions, seamlessly weaving content domains together. By building and supporting these connections, students develop a deeper grasp of the structure of mathematics and numeracy that supports math literate in the same way that they become language literate (attentive to the conventions of language, use of precise academic vocabulary, and gain insight into how language functions).

Mathematics is more than numbers, just as reading is more than letters. Language and mathematics comprehension involves placing words and numbers into meaningful milieus of daily living. Everyday activities create and support an environment for developing language, mathematical, CT literacies. Levels of mathematical understanding are communicated to others through language, and the ability to solve word problems rests on the domains of literacy.

Math literacy rests on language competence, from basic sounds to structures of text (Moats, 2010). There are critical reciprocal relationships between literacy and language; the ability of being a skilled reader is language-based and changes over time. Reading is essential for students to be successful in mathematics and in developing computational thinking (Purpura, et al, 2019). Exacting meaning from texts or word problems involve multiple levels of language and cognitive skills and processes (Oakhill, Cain, & Elbro, 2014). Often, when students have difficulties in understanding what they are reading (comprehension), it is not attributed solely to poor word recognition, but to language comprehension (Spencer, Quinn, & Wagner (2014).

So true is of computational literacy, as students decompose problem elements into simpler parts, look for patterns, remove details, define steps to solve an algorithm, they employ a broad range of analytic higher order cognitive processes that leads to solving math problems. By advancing mathematics, computational, and language literacies across K-12 education in New Mexico beginning in grades K-4, our students will be in a better position to understand their

digital world that primes them for future college and career success creating better lives for themselves and their communities (Smith, 2018).

Workings of the K-4 Mathematics Academy

STEM creates a synergy that brings disciplines together to provide direct experiences with natural phenomena. STEM content and processes are the key drivers that shape the educational focus of the K-4 Academy in community schools. It is in community schools that teachers and students have the "space" to develop a growth mindset that encourages them to try new things and make mistakes (Heggart, 2015). It is not the success or failure of ideas that is important, but what teachers and students learn as part of the process.

By centering on STEM, an ecosystem for learning-by-doing mathematics grows alongside CT and language. Such an environment encourages students to develop a problem-solving aptitude that encourages them to become active and engaged by putting their hands and minds to work, the results of math learning-by-doing is foundational to the K-4 Academy and contributes to an "I can do confidence" that is nurtured across the content literacies.

When students are more confident and less anxious about mathematics, their performance improves (Furner, 2017). One way to lower math anxiety and pique students' confidence in math, CT, and language is to incorporate math-themed children's literature. With the current emphasis on students communicating their thinking, language plays a key role in building students' confidence and mathematical and computational capacity to share what they know and how they know it (Furner, 2017a & b).

Academy Professional Development

The Academy professional development (PD) supports teachers in learning mathematics, computational thinking, and language protocols as they use multiple representations in ways that uncover students' oral and written communication from every day to more math-centered academic language and algorithmic reasoning (Schleppegrell, 2010; Moschkovich, 2010; Practice #6 in the Common Core).

1. Crucial elements to accomplish these PD goals is to include children's literature, stories, poems, and songs and related activities to bring relevance and meaningfulness to grade-level appropriate mathematics and ELA standards (Golden, 2007). Other key aspects of the PD are math talks, Math Circles, exploding dots, and teacher and student journaling to name a few. These along with other language-based math and CT strategies appeal to diverse learning modalities and offer opportunities to assess students both formatively and summatively. When implemented together, there is evidence to suggest that students are less anxious, think more deeply, and perform better in mathematics by finding productive ways to address complex problem situations (Rozalski et al, 2010; Qureshi, 2021), thereby increasing math reasoning and proficiency (Furner, 2018).

   In Barnaby's (2015) qualitative case study, the use of children's literature proved an effective strategy to teach mathematics and helpful to ameliorate math anxiety. The results from McAndrew et al.'s (2017) quasi-experimental study with second graders found that using children's literature, specifically, geometry-related, improved learning in geometry as well as their attitudes. Weinstein (2017) developed an all-inclusive list of math-themed children's

literature covering the Common Core Math Standards across the elementary grades. Literature with or without a math theme can be used to foster student math learning and thinking by focusing on the characters, settings, and plots in non-threatening and enjoyable ways, such as the book about *Tino the Tortoise* who takes a trip with his friends to the Grand Canyon.

The PD component of the Academy proposes to build supports for teachers as they routinely use "math talks" to foster students' daily language along with development of more precise academic mathematics language and computational thinking strategies (Schleppegrell, 2010: Mouza, et al, 2020). Students who are engaged regularly in math talks, for example, gain confidence in their math reasoning abilities when they share in their own words the strategies they used to arrive at their "answers and/or conclusions" (Parrish, 2014). These explanations shed light on where the math gaps are in student thinking and provide teachers with valuable information upon which to design future specific instructional interventions.

For students, math talks deepen their math understanding (Parrish, 2014) and for teachers, they offer opportunities to *recognize* emerging mathematical and computational thinking as students construct explanations that are shared with others, supporting validation of their thinking. There is the temptation to focus on the grammatical output rather than on. listening carefully for ways to confirm students' thinking. This formative information affords future planning ideas when revisiting math misconceptions and any homonyms (base, operation, mean, element, even, round, similar) that surface (Kenney, 2005). In addition to ensuring equitable participation, it is essential to vary language frames and vocabulary.

2. Math Circles, another approach, will be an intregal part of the Academy PD. It provides a mechanism for teachers to explore deeper ideas that students have around a common problem understudy (Math Circles, https://digitalcommons.cwu.edu/mathcirclesjournal/vol1/iss1/). There are many different types of math circles, but a common element of this approach is small groups of students working to uncover the underlying math structure of a given problem. Teachers along with their students are encouraged to ask questions, make mistakes, and challenge each other to reveal and explore new ideas (Joe, 2021; YouCubed).

3. Teacher coaching and forging partnerships are central features of the Academy. Coaching and team teaching offer continuity of professional learning that ensures that questions are answered to tailor what is presented during the PDs is implemented in real time with students. Participating teachers regularly meet either in-person and/or virtually in small grade level groups or individually with coaches who will assist in planning and implementing the PD strategies. Coaches also provide in class assistance, co-teaching opportunities, and additional resources as part of the ongoing support provided to Academy teachers.

These featured strategies have been field tested with teachers, students, and their families sponsored by MathAmigos, a community outreach volunteer organization (https://mathamigos.org; Taylor, et al, 2019). Many teachers, educational assistants, and students in the SFPS and surrounding

areas have attended these events. The MathAmigos team of mathematicians, educators, and teachers
share love for math and a desire to support school and classroom educators in many different ways
beyond hosting workshops that include Family Math Nights, Julia Robinson Math Festival activity tables,
and Teacher Collaborative Planning Working Groups, such as the I Spy Literature in Math as part of a
long term strategy to immerse childtren, their families, and teachers in math everyday experiences.

Benefits of K-4 Mathematics Academy

Early mathematics, language, and computational literacies underpin school and career success. But many students struggle to acquire skills in these content domains at rates similar to their peers. These three domains are interrelated and share basic underlying features (Whitin & Whitin, 2000). Even though there is extensive empirical evidence for developing and teaching these curriculum areas together, actual classroom implementation lags behind. The goal of the K-4 Academy is to position mathematics alongside language and CT to promote the linkages that they share through integration (Purpura, et al, 2019; Purpura & Logan, 2015; Purpura & Napoli, 2015).

Teacher Academy participants will enrich their instructional repertoire when they recognize that these literacies complement each other in ways that scaffold content learning. There is research to suggest that the proposed approach deepens students thinking, reduces their anxiety about math, language, and computing, encourages thems to share their ideas orally and in writing, and promotes an attitude that mistakes are a part of learning, all leading to increased learning (Zhang et al., 2019).

Metrics to Determine Student Progress

Qualitative and quantitative measures will be used to compare the progress of Academy students in math and language arts with those who do not participate. One qualitative measure such as a "smile quotient" will be used to identify the number of students and teachers who smile as they engage in math, language, and CT related activities. For Hoerr (2022), a simple smile can be quantified and used as a measure of success. Smiles on students' and teachers' faces express emotions that they are enjoying what they are doing, are confident in their roles, and approach others with a welcoming attitude.

In addition, the assessments from video-taped math talks along with peer and Academy staff in classroom observations will be collected and analyzed along with class formative and summative test data. These assessments will assist in determining the degree to which the strategies presented in the PD sessions were implemented and contribute to content knowledge proficiency. Also, district mandated test scores and other data from the NM Rise will be gathered and analyzed for participating students and compared with those who are not. Lastly, these data will shed light on identifying which best practices supported students' math, language, and CT learning.

Students in the Academy are part of a community of learners who share their math and computational thinking as they all learn math in more purposeful and productive ways across disciplines. Teachers who intentionally use all or a combination of the literacy strategies will offer their perspectives on how they taught mathematics with the goal of increasing their confidence and knowledge, leading them to profess that, "I can do it in ways that are more enjoyable and effective!"

This prospect can be a game changer for struggling students in mathematics and reading (Minero, 2019). In addition, it complements any textbook series, curricula, and/or resources that may be currently in place because it is less prescriptive and more flexible, begins where the students are, and builds on what is in place. The benefits abound when including literature, math talks, Math Circles, and other strategies that integrate mathematics, language, and computation thinking literacies are implemented in interactive classroom settings. These include: (1) contextualizing mathematics in stories; (2) implementing literacy domains of listening, speaking, reading, and writing in mathematics via shared experiences; (3) advancing a growth mind-set outlook that encourages unedited responses, welcomes mistakes, and reduces anxiety (Haimovitz & Dweck, 2017); (4) fostering historical, cultural, and real-world connections; (5) implementing a three-stage learning sequence (concrete-representation-abstract (CRA); and (6) assessing students' mathematics understanding through their comments, smiles, reading, and responses to sentence frames, prompts, and questions. (Furner, 2017a & b; Furner & Kenney, 2011; Furner & Duffy, 2002).

Summary

The Academy component of STEM+ attempts to prepare young learners in our state for a 21st Century world where they are confident in their abilities to solve problems and demonstrate through the development of their emerging math literacy. The consensus of much of the research on implementing the proposed literacy-language-CT-based approach to mathematics instruction is that it provides scaffolding for young learners to share their knowledge of numeracy by promoting their understanding of the structure of mathematics.

And mathematics is not a subject that is associated traditionally with language and CT literacies. The STEM+, K-4 Mathematics Academy has developed an innovative model that braids math knowledge and skills while reinforcing and enhancing language and computational thinking. The Academy program scaffolds math learning with literacy strategies because math is more than just numbers; it is

in ways that transform mathematics into words and back into numbers so student can tease out the meaning from mathematics and word problems, using stories, math talks, and Math Circles to bolster their insights, understandings, and master difficult math concepts.

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