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MVIP: Math Villages for Inclusive Practices: A Model to Engage All Students and Teachers in STEM Experiences

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MVIP: MATH VILLAGES FOR INCLUSIVE PRACTICES:

A model to engage all students and teachers in STEM experiences.

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ABSTRACT

The Math Villages for Inclusive Practices (MVIP) model supports inclusive practices through a) the inclusion of students with disabilities, specifically mathematics disabilities into STEM related activities, b) co-teaching of STEM related topics as professional development, c) "hands-on" real life problems to be addressed collaboratively with students and co-teachers.

MVIP model levels the playing field for students with math disabilities to be engaged in integrated STEM activities. Co-teachers support these activities through professional development that creates content-rich and differentiated instruction for all students. The village concept is derived from the membership of the village learners which includes students, special educators and general educators and community experts all focused and engaged in problem solving while exchanging information for the collaborative endeavor.

MVIP: MATH VILLAGES FOR INCLUSIVE PRACTICES

"Today, mathematics education faces 2 major challenges: raising the floor by expanding achievement for all, and lifting the ceiling of achievement to better prepare future leaders in mathematics, as well as science, engineering and technology" (AERA, 2006).

"If America is to sustain its international competitiveness, its national security, and quality of life for its citizens, then it must move quickly to achieve significant improvements of all students in mathematics and science." (Business-Higher Education Forum, 2005).

NATIONAL CONTEXT

Significant deficiencies in American K-12 mathematics education have been brought to light in many prominent reports e.g., A Nation at Risk (1983), Shaping the Future (George & Bragg 1996), TIMSS (1997), the Glenn Commission (2000), and PISA (2003). It is worth noting that these reports span over twenty years but the issues they address remain unresolved. The consensus of these reports is that over one-third of the instructors who teach secondary school mathematics in the United States do not have a major or minor in mathematics, mathematics education, nor in related disciplines. (Ingersoll 2000). Further those teaching secondary school core areas, such as math are typically certified in elementary education hold generic multiple subjects certificates.

Other studies claim that students' difficulties with math begin in grade 4 and that their interests in the study of math also begin to wane at that time. It is not clear which comes first, decline in achievement or loss of interest. Both conditions set the stage for math failure. Coupling this with the shortage of highly qualified mathematics teachers, yield a critical gap in the education of all students and in particular those with identified with disabilities.

According to Geary (2004), about 5% to 8% of students are identified with mathematics disabilities and hence eligible to special education services. In addition to specific mathematics disabilities students must also have been assed to have a psychological processing disability. Consequently, students with mathematics disabilities may also have visual and/or auditory processing difficulties. Geary, Hamson & Hoard (2000) (reported in Wiebe and Kim 2008) suggests that it is, in fact, difficult to determine the exact prevalence of math disabilities be due to the different definitions and over lap of diverse learning disabilities. Cawley, Parmar, Yan & and Miller (1998) reported that students with disabilities lag behind their typical peers suggesting one year for every two years of school attendance. Further, students with learning disabilities perform at about the 5th grade level in mathematics at the 12th grade chronological age. This takes on even greater significance as students leave high school to enter the workforce or postsecondary education without compensatory skills to be successful. Additionally, Witzel, Riccomini and Schneider (2008) suggest that success in high school algebra and other advanced math classes is becoming increasing important to today's students. This necessitates an early "attack" for math skills for all students. Coupling this with national and state movements to increase the mathematics standards, increase the number of mathematics credits taken in high school and raise graduation standards presents challenges for all students particularly students with disabilities, general education teachers in inclusive classes and special education teachers to provide appropriate accommodation and modifications. Poor performance in mathematics and other core content areas can be attributed in part to lack of students' interest in these subjects because the subjects are taught in a siloized disconnected fashion with minimal time for true exploration and learning. Students need opportunities to wrestle with" big ideas" and apply what they have learned to the solution of interesting and compelling problems, particularly those facing society and requiring application of workplace skills (Greeno, 1997; Kazis, 2005).

Mathematics educators and special educators agree that: (1) To enhance learning, students need more time on task; (2) Long-term projects that engage students in "hands-on" explorations and collaborations, and applications of mathematics to the solution of problems in other content areas, lead to deeper and longer-lasting understanding of concepts and skills; (3) Students can do more if challenged and expectations for their performance are higher; and (4) Focusing instruction in the lower grades on the development of key mathematical ideas that prepare students for the study of higher level mathematics, will result in greater success with the more advanced courses and concepts. It is this "opportunity to explore 'big ideas" and engage in "hands-on" projects that created the Math Villages for Inclusive Practices model (MVIP).

MATH DISABILITIES AND INCLUSIVE PRACTICES

The National Science Foundation this year reported that about 7% of the United States non-institutionalized population between 6-20 years old has a disability (NSF 2009, Table A-3, p.26). Taking higher-level math courses were generally associated with higher scores on the 2008 assessment at the 13 and 17-year-old level. Relative to students with disabilities the NAEP reported that the overall gains in mathematics since 2004 were seen for all age groups except for the lowest performing students.

With the momentum of inclusion, more students are being serviced in the general education classroom with adaptation and modification being provided by the special education team at the Individualized education Planning (IEP) meeting. The special education teacher is responsible for implementing the adaptations and modifications to allow the student with disabilities to access the general education curriculum. Additionally, more students, who otherwise are or may be eligible, are remaining in the general education classes. This may be due to parental refusal for special education or the desire to have their student educated in the general education class or students have yet to be found eligible. In all cases the special educator and general educator collaborate to provide standards and IEP based instruction to meet not only the state standards but also the annual goals and short term instructional objectives of the IEP. The conclusions of a working statewide conference in Iowa echoed the findings across the nations by stating that 1) there is a strong belief that students with disabilities can be successful in college core academic courses and later in a STEM careers, given appropriate education and the opportunity to participate alongside peers without disabilities in laboratory or other hands-on experiences and 2) educators are highly concerned that they are not providing students with disabilities the proper accommodations to ensure success. Also the majority of math teachers and special educators do not always know how to modify existing activities to provide a similar experience.

These two finding underscore the need for inclusion and collaborative teaching along with professional development for both general math teacher and special educators.

A critical gap exists in the education of all students and in particular those with identified mathematics disabilities. As mentioned previously, Geary (2004), reported 5% to 8% of students are identified with mathematics disabilities and hence eligible to special education services. In addition to specific mathematics disabilities students must also have been assessed to have a psychological processing disability. Coupling this with national and state movement to increase the mathematics standards and increase the number of mathematics credits taken in high school and raise graduation standards presents challenges for all students particularly students with disabilities, general education teachers in inclusive classes and special education teachers to provide appropriate accommodation and modifications.

Witzel, Riccomini and Schneider (2008) reiterated this concern by stating that the raising of math standards coupled with the achievement gap in basic mathematics skills places students with disabilities at risk without appropriate accommodations and modifications. Maccini, Strickland, Gagnon and Malmgren (2008) assessed the general education curriculum for secondary students with high incidence disabilities and concluded that in all educational settings, youth with learning and emotional disabilities frequently had difficulty in math. Gersten, Beckmann, Clarke, Foegen, Marsh, Star and Witzel (2009) underscored the fact that students' low achievement in math is a matter of national concern. They cited the National Mathematics Advisory Panel report that was released in 2008 summarizing the poor showing of students in the United States on international comparisons on math performance. Xin and Jitendra (1999) stated that problems of mathematics underachievement are greatest for student for students with mild disabilities and those at risk for math failure. In support of this the authors cited Cawley et al (1998) who reported that the math performance of 8-9 year old students with learning disabilities was equivalent to the first grade level and the performance of 16-17year old students with learning disabilities was equivalent to about the 5th grade level.

INTEGRATED INCLUSIVE INTERVENTION FOR MATH DISABILITIES

In terms of interventions to address math disabilities, studies tend to be inconclusive as a “standard” for instruction. However, there seems to be a trend towards in integrated approach, which includes multiple strategies from general and special education best practices. Obudo (2008) through a comprehensive review of the existing research literature found that there are four important factors in determining success in mathematics for students with learning disabilities. These factors were identified as 1) teacher training, 2) teacher attitudes and perceptions, 3) use of effective strategies, 4) use of assistive technologies and the application of an effective curriculum and differentiated instruction. Xin and Zhang (2009) concluded that students with learning disabilities or difficulties were able to achieve at a high level when provided with appropriate educational opportunities, including carefully designed problem solving instruction.

Bottge, Heinrichs, Chan, Metha and Watson (2003) discussed an approach to mathematics called Anchored Instruction. This Anchored Instruction approach has been extended to afford student the opportunity to apply skills to hands-on projects in technology education classes such as building skateboard ramps. This approach involved the collaboration and co-teaching of the math, special educator and technology teachers. Additionally Kunsch, Jitendra and Sood (2007) through meta-analytic techniques found that peer-mediated interventions in mathematics are moderately effective for improving students' mathematics performance. Enhanced Anchored Instruction was employed with students with math disabilities. Results revealed that although students with learning disabilities scored lower on pretests, their learning trajectories matched those students without learning disabilities. Further, a maintenance test administer weeks after instruction revealed that student with learning disabilities retained what they had learned.

This problem-based approach was also advanced by Jarrett (1999) by suggesting that instruction focus on "big ideas and interdisciplinary themes" to enhance learning for students with disabilities. Big ideas are important concepts or principles that help students to organize, connect, and apply component facts and ideas. When students learn scientific facts, ideas an processes as part of an overarching theme, or big idea, they are more likely to see meaningful relationships between science and other disciplines, as well as their own lives. (Salend, 1998 as cited in Jarrett 1999). Jarrett also proposes that interdisciplinary themes can link various science disciplines-such as biology, chemistry, earth science and physics-or related science to other subject areas-such as math. These themes integrate critical common concepts from multiple disciplines and support diverse teaching and learning strategies. Xin and Jitendra (1999) conducted a meta-analysis on the effects of instruction in solving mathematical word problems for students with learning problems.

The results indicated that word problem solving instruction improved the performance of students with learning problems and promoted the maintenance and generalization of the skill. Maccini, Mulcahy, and Wilson (2007) conducted a review of literature from 1995 to 2006 on mathematics interventions for secondary school students with learning disabilities. It was determined that a number of practices demonstrated significant gains for students with disabilities in math. These practices included mnemonic strategy instruction, graduated instructional approach, cognitive strategy instruction involving planning, schema-based instruction, and contextualized video instruction.

Xin (2008) suggested that introducing symbolic representation and algebraic thinking in earlier grades might facilitate a smoother transition from elementary to higher-level mathematics learning and improved secondary school mathematics performance for students with learning disabilities. Mabbott and Bisanz (2008) reported that poor multiplication fact mastery, calculation fluency and general working memory discriminated children with mathematics learning disabilities from typically achieving age-matched peers. The authors found that regardless of setting the teachers focused primarily on instructional practices that teach students how to solve word problems (e.g., visualization) but not on practices that encourage analytical thinking necessary to promote transfer of learning (e.g., use of analogy). Additionally the teachers reported that they provided one hour or less of problem solving instruction per week. (van Garderen 2008). Further, Obudo (2008) through a comprehensive review of the existing research literature found that there are four important factors in determining success in mathematics for students with learning disabilities. These factors were identified as 1) teacher training, 2) teacher attitudes and perceptions, 3) use of effective strategies, 4) use of assistive technologies and the application of an effective curriculum.

COLLABORATIVE TEACHING AS PROFESSIONAL DEVELOPMENT

Meeting the diverse needs of students requires methods of service delivery that incorporates collaboration between special and regular education teachers. In recent years, collaborative teaching has become a means for providing students with an appropriate public education in the least restrictive environment. Murawski (2003) proposed the following definition "co-teaching [exists] when two or more educators co-plan, co-instruct and co-assess a group of students with diverse needs in the same general education classroom". (p.10). Murawski (2009) in discussing co-teaching at various levels lists 6 essential components of co-teaching. These include 1) two or more adults, 2) both professionals, 3) working collectively, 4) delivering substantive instruction 5) to a heterogeneous group of students, 6) in the same space. These serve as the foundational components that inform the MVIP in terms of content and delivery of the MVIP approach to collaboration.

The extent to which co-teaching improves student academic progress has been a subject of many studies as well. For example, Walther-Thomas (1995) studied 23 schools, within eight districts, over three years with the following key effects: better attitudes about themselves and others on the part of students with disabilities who also improved in their academic abilities, remained in the general education population, had a greater desire to learn, became less critical, and began to see their own academic and social strengths. General education students benefit by receiving individual help and modifications through the collaboration between both teachers.

At the secondary school level, in a meta-analysis by Murawski and Swanson (2001), an overall moderate effect for student progress favored co-teaching. Student engagement, participation, student-teacher interaction, student-student interaction, and positive self-image were all indicators of increased student involvement in a study of secondary school co-teachers (Magiera, Smith, & Zigmond, 2005). At the secondary level, co-teaching brings a unique set of challenges. Along with the demanding curriculum, co-teachers face substantial challenges with the increased emphasis on content area knowledge, the need for independent study skills, faster paced instruction, high stakes testing, high school competency exams, less positive attitudes of teachers, and the inconsistent success of strategies that were effective at the elementary level (Mastropieri & Scruggs, 2001). Although many secondary teachers have mixed or even negative attitudes towards inclusive education, teachers in co-teaching relationships view inclusion favorably (Keefe & Moore, 2004).

Professional development (PD) efforts have been mandated, for general and special educators since the passage of PL 94-142 in 1975. Professional development efforts have included workshops, seminars, in-services, class embedded consultation, coaching, mentoring, and providing collaborative teaching opportunities to name a few. The National Staff Development Council (2009) found that research suggested that sustained and intensive professional learning for teachers is related to student achievement gains. Intensive PD, especially when it includes applications of knowledge to teachers' planning and instruction, has a greater chance of influencing teaching practices and, in turn, leading to gains in students learning. (Cohen & Hill, 2001; Desimone, Porter, Garet, Yoon & Birman 2002; Garet, Porter, Desimone, Birman, & Yoon 2001; McGill-Franzen, Allington, Yokio, & Brooks 1999; Supovitz, Mayer & Kahle, 2000, Weiss & Pasley 2006).

Researchers have found that teachers are more likely to try classroom practices that have been modeled for them in PD settings. (Snow-Renner &Lauer, 2005; Penuel, Fishman, Yamaguchi, &Gallagher, 2007). The authors reported "teachers themselves judge PD to be most valuable when it provides opportunities to do "hands-on" work that builds their knowledge of academic content and how to teach it to their students." (p.10). Further, Giordano (2005) found that teachers were more likely to change their teaching behaviors when the professional development program is grounded in practice, intellectual stimulating, collaborative, and sustained over time.

Further, successful PD opportunities 1) used multiple methods to the content to be learned; 2) tapped multiple level of cognitive development; 3) Differentiated options to learning. The MVIP embeds these successful components. Teachers have consistently, over the years, identified their immediate needs for further professional development in learning more about the content they teach (23%), classroom management (18%), teaching students with special needs (15%) and using technology in the classroom (14%). (NSDC 2009). The MVIP has grounded its PD in academic core content and meeting the needs of all students in inclusive classes.

In terms of problems-based professional development, mathematics educators agree that in order for more students to be successful with the study of mathematics, then teachers need a different type of training. If students with and without disabilities are to engage in long-term projects that require application of mathematics to the solution of problems in a variety of contexts, then teachers need to also have that experience in a co-teaching relationship. If we want all students in an inclusive setting to wrestle with tough ideas while they problem solve and persevere, and learn at point of need, then teachers must have that experience. If students are to learn collaboration skills- teamwork, respect for others' ideas, then teachers need to have that experience.

MVIP is a departure from current siloized, solo, and segregated teaching and professional development practices. It's theory of change, is grounded in empirically-based components that have been reported as effective in promoting achievement in mathematics for students with math disabilities; collaborative-teaching in inclusive secondary schools; and problems-based teaching of core content MVIP is a collaborative teaching model where students with and without disabilities and general and special educators are actively engaged with mathematicians and community professionals in "villages" that are content and pedagogically problem-based.

The vehicle of innovative professional development (PD) provides opportunities to collaborate will blend core content and differentiated instruction to excite and teach all students. Math and special educators engaging in Villages with university and community professionals to model collaborative problems-based curriculum provides a unique model for PD with direct class implementation.

Previous cited research highlights the pressing need for improving mathematics skills for all students, the call for collaboration among general and special educators for effective and appropriate instructional practices and the development of innovative professional development.

MVIP COMPONENTS and IMPLEMENTATION

The MVIP Model addresses: 1) the national and state concerns regarding teacher competency for instruction in core math areas in the secondary school through innovative professional develop in Math Villages, 2) the dismantling of siloized instruction through collaboration between general and special educators, and community practitioners through collaborative learning's 3) developing a sustainable professional development model for secondary school collaborative teaching in math and other core content areas that excite and positively impact instruction and achievement.

The MVIP Model blends the content expertise of the general educator and the adaptation and differentiated instruction expertise of the special educator to provide integrated instruction for students with math disabilities in inclusive settings. This takes on a critical merger for secondary schools departmentalized curriculum delivery. Typically, the special educator in the general education class attends to the students that have specific IEP objectives and assists other students as needed. However, these two cohorts of students distinctly have an affinity to their "teacher". Thus blending the roles of the two teachers while employing their expertise for all students yields a collaborative teaching relationship and environment. The Math Villages also provides an innovative opportunity for inclusive teachers and community practicing mathematicians to collaborate in a problems-based milieu to enhance the pedagogical content skills of both teachers through professional development and authentic modeling.

As a result of participating in The MVIP Model, student with and without math disabilities and special education teachers will have the opportunity to be more excited about and engaged in the learning and teaching of core mathematics and using of mathematics, to solve problems, general education teachers will have developed skills in adapting curricula to meet the needs of all students in an inclusive class.

The concept of Villages has been implemented through a National Science Foundation grant, "Priming the Pipeline: Putting Knowledge to Work" [1]. A "village" was comprised of students with varying degrees of ability and interest in math and sciences, secondary teachers of math and science, university STEM faculty, undergraduate mentors and community experts practicing in the STEM fields. These 'Villages' met after school approximately 2 hours for 9 sessions. In essence, there is a level playing field for the all students as information is available on at the "point of need" and problem based leaving is occurring collaboratively.

Village theme aligned with the expertise of the village leader-usually a university faculty or community practitioner. Themes included:

Cellular Network Development-The task was to locate a community of 50,000 inhabitants and to strategically position cell phone towers to support the developing community. Villagers needed information regarding capacity of towers and their switch blocks, the cost and projections over 5 years. Further, the cell phone towers needed to be camouflaged so they the environment was not disturbed.

Clean Room Exploration and Model Design-The task was to build a replica clean room with all appropriate biohazard precautions. The final test was to analyze artifacts collected from the community as to their level of contamination.

Documentary and Film Production-The final product for this village was the production of a 3-minute documentary of the students' choice. Issues regarding lighting, sound and editing were presented and addressed.

Engineering Design: Rockets and Sumo Robots-The villagers worked in teams to create rockets that would propel vertically and sumo robots that would engage in "battle" with other developed robots. The engineering technology included velocity, force, impact and computer programming for detection.

Wind Turbine Design-This village was challenged to build a wind turbine to produce wind energy. Within this village students and teachers needed to calculate wind force on buildings, determine where wind was the most abundant through analysis of anemometer readings. The teams then had to develop am economic model for using wind power as electricity with the accumulated data. This also included the selection of a site, worldwide, that would benefit most from the wind turbines.

Visual Programming and Gaming- In this village, the teams collaborated to crate computer games. Here the villagers explored principles of computation including decisions, iteration, commands, variables and data types. Two dimensional coordinate, points, lines and random numbers were employed to move objects in a gaming situation.

The model presented in this paper underscores inclusive education within a "village" model while highlighting co-teaching as professional development for inclusive practices. Students with math disabilities benefit from the collaboration, acquiring information at the at the point of need and through collective problem solving. Each village utilized a multisensory approach as well as emphasis on multiple intelligences model to present information. As students and teachers progressed through the knowledge and skill development, information was presented as the teams encountered a roadblock to information. The integration of the STEM facilitated the students' understanding of the interconnectedness of the disciplines.

Preliminary data indicates that students have increased their interest in STEM classes by enrolling in increasing difficult math and science class at their high schools. Further, students have persisted in their interest on STEM classes as they continued in a sequence of science and math classes. Finally, students are pursing STEM majors as they enter higher education. Extrapolations of this model to the classroom suggest that general educator co-teachers feel greater confidence in teaching students with disabilities and collaborating with the special educator while special educators have a greater understanding of math and science principles and content. The various components of "villages" exist in each school. The task is to integrate the components into a well developed whole. Collaborative teaching has been shown to be an effective teaching methodology for inclusive classes. Teaming the special educator and the mathematics instructor at the secondary level will involve planning and scheduling. Once the classes are blended the "Villages" takes shape with thematic problems to be solved with STEM skills. The interrelationship of the special and general educators further enhances the content and differentiated instruction of each educator respectively. The introduction of a community expert provides additional professional development information for both teachers and provides a "real world' element for all students.

Utilizing a "village" concept underscores the integrated nature of STEM skills, supports the collaboration between educators and addresses the unique learning approaches of all students in a cooperative milieu. The presented Village is one theme and variation of model of inclusive classes. The various elements can also be implemented independently with progression towards full implementation.

The overall goal of MVIP is the creation of a collaborative-teaching village culture in secondary and high school schools that promote the excitement, knowledge and skills necessary for general and special educators to promote and assure success *for all* in school math programs. Specifically through MVIP teachers have the opportunity to increase general and special education students' excitement about, engagement with, and achievement in mathematics; develop Math Village experiences that support student achievement and acquisition of problem solving and critical and flexible thinking behaviors; increase competence by co-teaching (mathematics experts and special education experts) in Math Villages to model content and pedagogy for secondary mathematics; create an authentic milieu to model co-teaching in a Math Village experience 3) Develop Math Village content that addresses "Big" math problems for students with and without math disabilities; establish a model Math Village for students with and without math disabilities with hands-on experiences in an inclusive environment.

As a result of participating in a MVIP type model, special education teachers will be more excited about and engaged in the teaching of core mathematics and using of mathematics, to solve problems, general education teachers will have developed skills in adapting curricula to meet the needs of all students in an inclusive class.

The National Council of Algebra Teachers (2007) declared that the greatest challenge to teaching was to motivate the students. Through these "village" paradigm-students and teachers have the opportunity to be motivated through inclusive practices, collaborative learning, and problem-based integrated learning.

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