Mathematics Education and the Mathseeds Program

Mathseeds Overview

Early Development of Mathematical Thinking

In an era in which the development of mathematics and science skills have become a central concern, the early development of mathematical thinking stands as a vital goal for parents and educators It is hard to think of any work that does not use mathematical thinking while a high level of mathematical knowledge and skills are required for success in any STEM career. Numeracy is coequal to literacy in the new Core established for public schools and followed by many private schools and homeschooling programs in the United States.

The Common Core State Standards (CCSS) consist of five strands. In the primary grades, emphasis is given to number sense and operations, although geometry and measurement appear. Number sense provides the vital foundation for later understanding algebra. Primary school teachers and administrators, and parents overseeing homeschooling programs and programs supplementing school work focus intently on ensuring students develop strong, flexible number sense. As a result there is an ongoing demand for educational programs based on current CCSS-based best practices in mathematics teaching, to promote the best outcomes in mathematics learning.

Shifts in Mathematics Education resulting from the Common Core State Standards

Studies have determined that, while close to 90% of high school math teachers believe their students are ready for college math, only 26% of college-level instructors feel their incoming students are properly prepared.[1] New research suggests that establishing strong math understanding and number sense by grade 3 is critical, with each semester a child falls behind taking a full year to remediate. The CCSS for mathematics provide guidance to educators with the goal that all students, from pre-school to high school have the opportunity to learn the 'core content' of mathematics that will properly prepare them to succeed..

Success in mathematics requires three essential shifts in planning and implementing mathematics curriculum, in comparison to previous approaches[2]:

- A Shift in Focus: Educators focus on content from the strands in the Common Core Standards.
- A Shift in Coherence: Educators present content in a way that assimilates and builds on learning from one grade to the next, and from topic to topic within a grade.
- A Shift in Rigor: Educators give equal attention and rigor to all aspects of a topic –understanding concepts, developing fluent procedures, and applying concepts in varied contexts.

Mathseeds provides parents and teachers with research-based materials that incorporate these shifts in teaching while delivering the content presented for K-3 by the CCSS. Mathseeds can be counted on to provide materials and instructional systems that support parents and teachers, helping them apply these three shifts to implement the Common Core State Standards.

Mathseeds is Built on Sound Teaching Principles:

Originally developed in Australia, where some of the most innovative research on early child development and education is currently being done, Mathseeds has been designed to ensure students are given the best chance to develop e high levels of number sense and operations and begin to think mathematically. In keeping with the new shifts promoted by Common Core Standards, each Mathseeds lesson provides practice and application in one or more aspects of number sense and operations. The materials are in line with the key shift in mathematics education promoted by the CCSS standards. the Mathseeds system provides linked and integrated approach to learning mathematics, rather than rote skills without actual number sense or mathematical fluency.

- Mathseeds lessons align with CCSS-based expectations
- Mathseeds lessons lead to an in-depth understanding of mathematical principles
- Mathseeds lessons reflect the progression of mathematical learning found in CCSS-defined strands and knowledge clusters
- Mathseeds is an integrated, organized system that complements CCSS-based programs while providing an independent learning resource to children in CCSS-based programs and in homeschooling programs

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III Development of Mathematical Thinking

Functionality is more complex than any list of specific tasks such as balancing a check book or projecting gasoline requirements. The mathematical demands of everyday life, especially in the quantitatively demanding US society, require more than basic numeracy.

(Madison, Bernard L. and Steen, Lynn Arthur, 2008)

In a world demanding higher and higher levels of mathematical competence at all levels of society, the teaching of math has become a matter of critical importance. National and local governments, businesses, educators, and parents all have a vested interest in ensuring children be given the best and most effective training in math skills possible. Common sense and rigorous studies both suggest that the first years of a child's education serve as a critical foundation for their achievement in all the years to come.

Considerable energy and effort has gone into determining what best practices will most effectively help students develop the skills needed to survive and thrive in a math-sensitive world. Studies around the world have offered concrete suggestions to improve teaching methods and to help instructors develop powerful learning approaches for even the youngest children, promoting a level of fluency in youth that will serve as a strong foundation as students mature. Number knowledge and the early development of mathematical understanding is key to later developments.

> This ···argues that in the early development of QL, there is a specific corpus of numerical knowledge which learners need to integrate into their thinking, and to which teachers should attend. The paper is a rebuttal to historically prevalent (and simplistic) views that the terrain of early numerical understanding is little more than simple counting devoid of cognitive complexity. Rather, the knowledge upon which early QL develops comprises interdependent dimensions: Number Knowledge, Counting Skills and Principles, Nonverbal Calculation, Number Combinations and Story Problems - summarized as Number Sense.
> (McClellan 2012, Volume 5, Issue 2, Article 3)

New Common Core State Standards (CCSS) are aimed at promoting the development of strong number sense as well as mathematical skills in young children, ensuring they will be prepared to build on sound foundations in the years to come. The educational system offered by Mathseeds is a methodical supplement to public instruction or private home schooling designed to supplement and support CCSS standards and teaching principles.

The Mathseeds package of lessons and activities is consistent with the three key shifts in math education promoted by the CCSS. These shifts are the engine that drives the new CCSS approach to math instruction. Awareness of the shifts and understanding of what they mean for parents and educators is vital if they are to help developing students get the most out of the new teaching.

FOCUS:

The first of the three shifts is the shift in focus. Where at one time schools attempted a "buffet-style" spread of the most possible math exposure in early years, with very little depth or development of understanding, the new CCSS standards aim at a more selective targeted approach to early math education. The goal is to encourage young students to think deeply and extensively about what basic numeric concepts mean, and how they work.

Mathseeds reflects this shift in approach, offering lessons designed to mirror the new narrowed focus, reinforcing a child's experience of numbers and number concepts. Lesson exercises have been developed to ensure students are offered a range of approaches to the use of this vocabulary of ideas and skills

through challenging, entertaining problems. The ideas and skills dealt with conform to narrow focus, while the approaches and exercises offer diversity and interest, providing a wide array of ways to present a narrow field of mathematical thought and method.

Coherence:

The new CCSS standards require that math education is not only horizontal—designed to be unified and constant in career. The skills, concepts, and understanding developed through CCSS s is intended to be woven into a unified whole that builds strength upon strength over years.

Many educational supplements fail to reflect the CCSS progression and the unified coherence of the system throughout the years of schooling. Materials are presented out of order, or without sound integration with the thinking and instruction going on at that grade level in any other class or school following CCSS. The orderly, interwoven integrity of a coherent vision is eroded or even destroyed by instructional material presented out of time, out of place, and without context.

The materials provided with Mathseeds ' instructional design is consistent with the overall integrity of the CCSS-aligned materials. A student educated using these materials should remain in sync with the overall progression of peers in other CCSS contexts. A child working in a public school with home school supplements, for example, will not be confused or distracted by jarring disconnects between school work and home supplements. A student who leaves school to be home schooled, or who shifts from home schooling back to classroom education will experience very little disorientation in making the transition. Students will have the content, skills and understanding expected by the CCSS at K-3..

Rigor:

The new approach to math education seeks greater underlying sense of mathematics. Prior approaches often made rote competence in techniques and superficial knowledge of key concepts a goal, hoping that the wide breadth of subject material and years of repetition would ultimately be interpreted and integrated in a student s' understanding. The new CCSS priorities make the understanding and integration itself a direct goal, rather than a side effect of rote learning.

There is a difference between being able to perform many things well without knowing why or being capable of applying them appropriately to solve problems, and knowing fewer things but understanding them on a profound level. Principles understood are more easily applied and adapted to new information. Understanding makes future learning simpler, more secure, and more effective.

Mathseeds lessons and exercises have been developed to serve as an illustration of the concepts the CCSS standards also convey. As primary or supplemental instructional material, they reinforce the core mathematical reasoning students must master to be able to move on with ease and confidence. Students working with Mathseeds at school or at home will be developing their comprehension of the material the

After taking the three shifts in instruction into account, the new CCSS-compliant educational materials are also organized into five specific areas of instructional material. This is not so much a shift in style and priority of teaching methods, but instead a way of organizing and pursuing mathematical learning. Like

sorting different sized nails in a work shop, or different styles of shoe in a shoe store, the CCSS standard sorts mathematics into what it calls "strands" of mathematical thought and skill.

The Five Strands of Mathematical Knowledge:

- Number sense and operations
- Algebra
- Geometry
- Measurement
- Statistics and probability

These strands are constant throughout the CCSS standards, and each has instructional roots that extend from the earliest levels of teaching through the highest order of material presented. These five strands are present throughout all grade levels. The CCSS material builds on these five areas of mathematical thought throughout any single year, and throughout the entire integrated arc of development through a student's education.

Because of this, it is important that educational curricula and supplemental materials recognize the same five strands of learning, organizing their materials to reflect the same classifications and lines of reasoning. This can be challenging, not least because many teachers and parents are not all that clear on how these organizational divisions work themselves—and, yet, failing to match the classification system can lead to confusion and conflict in teaching order and teaching focus.

The Mathseeds educational system, lessons, and exercises match the system of organizing mathematical skills and thought, and offer instructional materials and practice work that harmonizes with CCSS classifications and progressions. Instructors, tutors, and parents can feel sure that the material they are working with is consistent with that found in CCSS-based programs throughout the United States. Students can work at their own level, but will be able to do so without drifting from the shared understanding of math their peers enjoy.

This is important for student confidence and for the student's ability to eventually integrate with others in a world of math users. Just as it is vital that all people using the roads share an understanding of traffic law and driving technique—for example, what side of the road to drive on and what various lights and street signs mean—in a similar way math users depend on shared understanding and classification of knowledge and skills. This shared understanding makes communication, collaboration, and shared understanding possible.

The five strands provide a simple and understandable way of classifying different kinds of mathematical reasoning and application. Number sense and Operations deals with the underlying knowledge of numbers and how they can be broken apart and put together in many ways. This is the basis for what is commonly called arithmetic. Algebra deals with systems of equality and inequality, and the use of formulaic equations to solve problems. Geometry deals with a specific subset of logic dealing with space, forms, and two- and three-dimensional reasoning. Geometry knowledge depend on the ability to understand how spatial relationships work, and how a sound knowledge of the rules of these relationships can provide powerful tools for solving otherwise challenging problems. Measurement knowledge is focused on the many ways we measure our reality—measurements of distance, volume, time, temperature, and so on. Finally, Statistics and Probability deal with the ability to assess and

compare frequency and comparative odds. This last is one of the most crucial areas of knowledge in our modern world, and too often one of the least well understood. CCSS-based programs provide instruction in these areas of knowledge from the earliest years onward.

Mathseeds recognizes these classifications, and provides lessons and practices using the five-strand system of classification. A student taught using these materials will be consistent with the best practices used to instruct other students in CCSS-compliant systems.

IV Mathseeds Is Built On Sound Practices of Mathematical Instruction

Regardless of system or organizing principle, all successful teaching systems depend on certain best practices for educating, motivating, and encouraging students. These principles have been developed over generations of academic research, empirical observation on the part of teachers and parents, and tested outcomes of various teaching techniques.

Motivation and Rewards

> Common sense and cognitive theory concur: Interest and engagement lead to robust learning. (Edelson & Joseph, 2001)

Few adults are able to learn, and learn well, if they're not strongly motivated to do so. Only maturity and severe discipline can overcome a lack of motivation—maturity and discipline young children do not possess. Anyone who wishes to educate the young must first be able to motivate and encourage them. Strong programs depend on strong motivational systems. (Ames, 1992; Huitt, 2001)

> It is the responsibility of educators to do more than let children play or respond to teachable moments.
> Ginsberg, Lee, & Boyd, 2008)

To be optimally effective, educational programs must be able to motivate and reward students. Different students, however, respond to very different motivational and reward systems. As a result, resilient programs must make use of a variety of motivating elements, and offer diverse rewards.

Mathseeds is structured around the importance of motivating student to learn. The designers have provided lessons and exercises that encourage students to focus powerfully on the material, and to give time to understanding the problems presented and the information provided. Built-in reward systems ensure that students engage with the learning environment every step of the way, promoting stable, systematic mastery of the foundational math skills and comprehension suitable to their age and grade level. High-interest, compelling reward and motivational elements come into play at the completion of exercises, ensuring students complete materials to obtain desired rewards.

Perhaps the most important motivational element of education is actual student interest. (Renninger, 2000). Mathseeds is designed to be inherently the most interesting, and therefore the most motivating program possible. This carefully planned package of materials balances challenge against confidence and

security, offering new realizations, interesting presentations and frames, exciting practice activities, and final rewards to promote enthusiasm and excitement on the part of young learners.

Young children want to succeed mathematically. While few understand the importance or power of numeracy in a world that is increasingly dependent on STEM careers and mathematical fluency, children do understand that mathematics ability is important, just as they realize reading is important. They want to master this adult skill set. Like any person, they want to succeed and do well. Young children depend on adults, though, to provide the conditions that make success possible and learning exciting. It is up to teachers, parents, and other supporting adults to give children the most powerfully encouraging learning experience possible.

Lesson Progression

Mathseeds provides a total of 140 integrated lessons that progress from the earliest levels of math acquisition at the preschool level through second grade. Each lesson focuses on a single mathematical competency, providing instructional lesson material, a practice activity, and a reward in the framework of play and challenge. Geared to young children, the lessons and activities are amusing, age-appropriate, and exciting for their target audience.

These lessons are planned to coordinate with the CCSS standards already in place for each stage of a child's development. Lessons and activities intended for preschoolers focus on giving children the basic entry level skills and understanding that will give them a steady head-start on entering the grade system —or on beginning a separate parallel track through a home schooling system.

Lessons include materials focusing on counting, measuring, spatial awareness, equalities, and basic math functions like addition and subtraction. Practices are framed as games and activities, and can be adapted to adult participation in the lessons and practices.

Number Sense

All Mathseeds lessons and activities are designed to increase a child's number awareness and number sense. The materials involve students in an environment in which they naturally use their existing number sense to determine successful game strategies in their activities, using the additional new information provided by the lessons and instructions. The outcome of this process is the growing mastery of understanding and skills in a setting that makes it easy for a child to experience math as a positive and beneficial tool they can use to their own advantage and reward, rather than an imposed trial they must endure and suffer through to gain release.

This system encourages children to relate to math as a desirable edge in their own play and exploration. Just as children can and do recognize strength, or speed, or dexterity as tools they can use to succeed in their games and projects, they are encouraged to see math understanding and math skills as a beneficial advantage they can use to their own benefit.

As a result, children are encouraged to familiarize themselves with math and math skills, and to understand them. The system offers increasing rewards: the more a child learns and integrates, the easier and more effective their activities are, and the more they succeed. With practice they develop

strong, and authentic number sense based in actual ongoing use of their skills and information. Their mastery is based on true understanding and familiarity rather than on rote learning.

Variety of Instructional Formats

No two children are identical in their interests, their abilities, or their learning styles. Similarly no single child is "the same" every day, or wants to proceed the same way every time they learn or play. Variety of instructional formats ensures the broadest number of children will be exposed to those teaching methods best suited to their own learning strengths, and that all children will experience a variety of formats. This ensures that their experience of the Mathseeds educational materials remains fresh, exciting, and effective.

Each Mathseeds unit consists of an online animated lesson using recurring characters, and is followed by a variety of different activities designed to encourage children to make use of the information presented in the animated lesson. Children earn rewards from successful completion of activities, and those activities can be repeated, serving as diverse types of learning game. The final element of the package is a read-aloud story reinforcing the material covered in the lesson. The online program also provides a math-facts resource designed to both inform and challenge students, providing competitive activities that over time help a student perfect those skills that are most useful when automatic: addition, subtraction, multiplication, division, and similar rote-learning reflexive skills.

V Mathseeds Encourages Parental and Teacher Involvement

Children learn best for and with the adults in their lives. No reward system can match the reward children take away from adult mentoring and instruction. Studies have suggested that adult support and involvement in all areas of education can have powerfully beneficial consequences.

Not all educational supplements, however, are "adult friendly." Many computer-based systems develop a strong and enclosed tie between the student and the activities, with little or no room for adult support and interaction. As a result children lose all the benefits and insights that are gained when an adult talks part in a child's learning.

The beginning and end elements of each lesson are designed to be strongly adult-friendly. Teacher and child, or parent and child can watch the instructional animation together, commenting on events and discussing the lessons suggested by the narrative. During activities adults serve as advisors and cheerleaders, while the child is given an opportunity to show off skills gained. There is even the opportunity for competitive completion of activities, with adult and child taking turns on practice sets. The final stage, a read-aloud book telling a story that reinforces the material learned and practiced, is an ideal chance for parents and teachers to interact with child learners, as both adult and child enjoy the process of storytelling.

The Mathseeds system allows for extensive activity by an independent child, but is easily entered into by adults, also. By making both elements part of the learning process, Mathseeds provides an exciting

alternative to one-style learning systems that are either largely adult-exclusive or which are almost entirely adult-dependent. The level of adult involvement can be varied according to need, while still allowing and encouraging considerable participation.

VII Assessment and Reporting

Assessment and reporting systems provide framework and landmarks necessary for students, parents, and teachers to evaluate student progress and to plot out future paths to advancement. Assessment techniques have been established internationally as key elements in teaching.

The South African educational system, which struggled for many years with quality of instruction in their math and science curricula, has since 2005 pursued a curriculum focused on improvement of their educational techniques and materials that places profound importance on the assessment and reporting stages of education:

> Assessment in the National Curriculum Statement is an integral part of teaching and learning and should be included at all levels of planning. In the NCS, assessment is not simply an 'add on' or something that happens at the end of the learning process.
>
> The Assessment Standards in each Learning Area define the minimum requirement for achieving the Learning Outcomes at a specific grade.
>
> (National Curriculum Statement Assessment Guidelines for General Education and Training (Intermediate and Senior Phases) Mathematics; Department of Education, South Africa)

The South African program Number Sense, which has provided outstanding support to these curricular changes, was in large part developed by Aarnout Brombacher, internationally known for his work on assessment in not only education, but in engineering and in business settings, has made headlines in the world of math and science education. At the core of their success is the importance of assessment in the development of number sense in formative early childhood education.

Mathseeds provides multiple methods of assessment. Games offer immediate, interactive reporting—students know instantly if they've gotten the correct answer or not. Students also can see cumulative results of their efforts, as they earn awards and certifications. At the same time their progress is reported to parent and teacher dashboards, so that adults can see an overview of a student's progress and determine areas that need further work and support. In an assessment system that weaves through the entire multi-less program, parents, teachers, and students are offered strong, constructive feedback in positive forms that encourage further development and growth. Where many assessment systems do more harm than good, Mathseeds has developed a system that provides creative positive support for learning in the critical early years of math instruction.

VI Mathseeds Curriculum Overview

(Joyce and Lynsey: As I stated previously, IMO the existing overview of the program is quite good, and it would be only sense to preserve it to maintain brand identity and uniformity. I am quite willing to do an

original rewrite if the client feels otherwise, but from where I sit it would be a waste of their previous investment to fail to recycle this particular material as boilerplate. I've included a brief intro, and then just cut and pasted. Again, if you or the client want this material reworked into a fresh write-up, I will be happy to comply. Peg)

The Mathseeds program of online mathematical instruction and activities is comprised of a total of 140 lessons that take a student from preschool through second grade. This four-year arc of integrated materials is consistent with the CCSS standards of math instruction.

Pre K

Lessons 1 - 20

The first 20 lessons are for children with little or no mathematical skills. Children learn fundamental number skills including number recognition, number words and counting. The Mathseeds characters led by Mango introduce a range of skills including recognising the shape of each number 0-10 and one-to-one correspondence. Children are also introduced to the four basic 2D shapes: circle, square, triangle and rectangle, colours and some simple concepts of size: big, small, short, tall etc.

Kindergarten

Lessons 21 - 50

Lessons 21 - 50 develop growing mathematical skills. Children learn to count forwards and backwards to twenty with confidence. They use a range of techniques including ten frames and number lines. They also learn the number words up to twenty. Addition is introduced and children add up to ten and doubles to five. Mango and the other Mathseeds characters present the concepts of passing time, life cycles and days of the week during these lessons. Children develop their understanding of 2D shapes by sorting them according to their properties. They are also introduced to four 3D shapes: sphere, cube, cone and cylinder.

Year 1

Lessons 51 - 100

Mathseeds Lessons 51 - 100 build on the skills children have acquired earlier in the program. Children learn to count to 100, order numbers and identify ordinal numbers to 10th. An understanding of place value is developed, including trading ones for tens. Children identify money – notes and coins, and investigate fractions, focusing on wholes, halves and quarters. Subtraction is introduced, and children initially add and subtract to 10, and then to within 100. Strategies include counting on, counting back, near doubles and using number fact families. Children learn how to skip count by 2s, 5s and 10s, as well as early multiplication and division skills of grouping and sharing. The

concepts of area and volume are introduced in these lessons, and children continue to investigate the features of 2D shapes and 3D objects. Children follow simple directions to a particular location and learn to read digital and analogue clocks to the half-hour. Tally charts and simple picture graphs are introduced. Children also work with the concept of chance and the likelihood of things happening.

Year 2

Lessons 101 - 140

Mathseeds lessons 101 - 140 introduce a range of new concepts and consolidate skills taught previously. Children learn to count to 1000, identify odd and even numbers and round to the nearest 10 and 100. They continue to develop place value skills; composing and decomposing numbers to 999. Addition and subtraction strategies are further developed, including the 'jump' and 'split' methods, as well as vertical addition and subtraction. Children continue to practise grouping and sharing and use of the multiplication and division signs. They are also taught how to find fractions of a collection of items. Children investigate length and are shown how to measure in metres and centimetres. They investigate the way 2D shapes move and reflect, as well as how 3D objects are constructed. Children tell the time to the quarter-hour and the nearest 5 minutes, and use a calendar to identify particular dates. They construct tally charts and simple picture graphs, and interpret data in a variety of ways.

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[1] Professor William McCallum; Jason Zimba, PhD, Achieve the Core: Introduction to the Math Shifts of the Common Core State Standards; The Mathematics Standards: How They Were Developed and Who Was Involved, https://vimeo.com/92784226, achievethecore.org

[2] Ibid.