



Mathseeds White Paper

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WITH KATY PIKE



Mathseeds 

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Executive Summary

Mathseeds is an innovative teaching and learning programme that focuses on the needs of pupils learning mathematics in Reception to Year 3. The programme has been carefully structured to support individual learning by combining pedagogical research on number sense; child development; technology; motivation; and key curriculum initiatives. Taking into consideration the needs, learning styles and future direction of learners in the 21st century, *Mathseeds* combines a highly motivational play-based online context with structured sequential mathematical lessons. At the core it is a teaching and learning sequence consisting of 150+ lessons where key concepts in mathematics are taught, explored, practised and assessed. Alongside the core lessons are fluency and assessment components, as well as rewards and a range of teacher resources to guide pupils towards their most successful mathematical future. It seamlessly connects learning between school and home across a range of computer devices. Teachers are able to monitor and report on both whole class and individual pupil progress, and provide useful feedback to pupils, parents and other key stakeholders in their schools. *Mathseeds* is carefully designed to motivate and maximise pupil learning to provide the strongest foundation to achieve lifelong mathematical success.



National Climate

Recent studies conclude numeracy skills in the United Kingdom have deteriorated between 2003 and 2011, sparking renewed debate on the importance of numeracy skills for future social and economic success (National Numeracy for everyone, for life, 2016). Teachers of mathematics have a responsibility to foster interest in mathematics to “open up the possibility of mathematics being something that they want to pursue beyond what they are *required* to do” (Askew, 2016, p. 1).

Mathseeds offers teachers an engaging, well-structured programme designed to motivate pupils to want to learn mathematics. By positioning mathematics as a highly interactive tool for problem solving and reasoning, mathematics becomes part of how pupils think and experience success.

The *Mathseeds* programme demands a high achievement in mathematics learning in line with the government’s determination to make mathematics a priority in schools. This begins in the early years of learning. From the first national curriculum in 1989, the government committed to helping children to “delight and wonder” at mathematics (p. A3) and in the 2016 *Educational Excellence Everywhere* (2016) paper they re-affirmed this commitment for all pupils.

To teach a more challenging curriculum in the primary years, research supports evidence-based teaching alongside developing mastery (Department of Education, 2015, p89). This involves building a solid foundation in maths and quantitative skills. Research demonstrates these skills can be transformational for future generations in their social, cultural and educational settings (National Numeracy for everyone, for life, 2016).



Number Sense

Children develop their mathematical abilities following natural learning progressions with number sense being a formative platform for numeracy success (Back, Sayers and Andrews, 2013; Clements & Sarama, 2009; Klivanoff, Levine, Huttenlocher, Vasilyeva & Hedges, 2006). Broadly, number sense is the “understanding of number needed by children if they are to succeed in mathematics” (Howell & Kemp, 2006). It encapsulates counting abilities; number patterns; estimation; sequencing; connecting counting to cardinality; and number manipulation.

In their research, Cain, Doggett, Faulkner & Hale (2007) outline seven key components that are core to number sense. *Figure 1* shows these components: quantity/magnitude; numeration; equality; base ten; form of a number; proportional reasoning; algebraic and geometric thinking. Faulkner (2009) asserts that ultimately these components of number sense operate as a useful framework in visualising the interconnectedness of the principles of mathematics. It is important to view this not as a progressive model but rather as each component is connecting and therefore integral to each lesson.

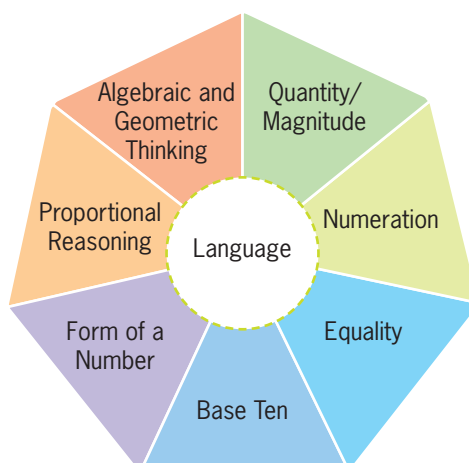


Figure 1: Cain and colleagues (2007) identified seven core components of number sense.

Strong number sense has been shown as a precursor of future mathematical success (Back, Sayers and Andrews, 2013; Jordan, Kaplan, Locuniak & Ramineni, 2007) with the suggestion it may prove to be to mathematics what phonemic awareness is to reading (Gersten & Chard, 1999). To help nurture the natural learning progress of number sense, pupils need to explore numbers and engage with them using multiple presentations and a wide variety of different activity types.

Mathseeds recognises the importance of number sense and the strong developmental role it has for setting the most successful trajectory in mathematics. It situates number sense activities in scenarios that are familiar such as playgrounds, kitchens for cooking and shopping adventures. In doing this *Mathseeds* provides a playful environment to explore and interpret the quantitative concepts of number sense. This playful format also allows for number sense concepts to be presented and explored by pupils in a variety of ways. The sequence of lessons in *Mathseeds* supports children by continually revisiting concepts and building on earlier skills in a way that deepens their understanding. This provides a strong foundation for more complex mathematical processes to come.

“Number sense ... shapes children’s mathematical futures and potentially their life chances, from their earliest engagement with mathematical learning.”

Rebecca Turvill, Brunel University, 2016

Programme Features

Key Elements

Research has indicated that several principles and critical factors underpin the most effective mathematical pedagogy and instruction. These principles include motivation and engagement; building on pupils' thinking; making connections; structured lessons; tools and representations; feedback; and assessment for learning (Anthony, & Walshaw, 2009; Jensen, 2005; Sullivan, 2011). *Mathseeds* combines each of these into an engaging environment for young children. The programme focuses on pupil interaction and features a wide variety of short instructional videos and highly motivating activities. Pupils continually earn rewards which encourages active participation.

All *Mathseeds* lessons follow a similar structure. Each lesson focuses on a particular mathematical competency, with instructional lessons being taught by one of the five key characters. The programme offers pupils opportunities to engage in practise and review activities, with up to 12 parts. Initial lessons build on the pupils' early mathematical experiences and focus on developing number sense. Other lessons focus on operations and algebra, geometry, measurement and data.

Mathseeds Lesson 14 has 12 instructional parts and activities. The lesson introduces the number eight. It has as a strong instructional focus on the early skill of one-to-one correspondence which is an important prerequisite to rational counting (Rays, Lindquist, Lambdin & Smith, 2012). *Figure 2* shows this teaching activity in action. Mango the monkey and Silky the spider help children identify the number eight visually and by name. Various activities follow that reinforce the number's name and shape, and pupils identify number eight both in isolation and when presented as one of three other numbers. Pupils count one item at a time to reinforce the concept of cardinality. *Figure 3* shows this teaching activity in action.

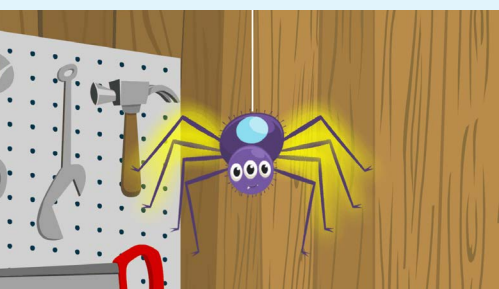


Figure 2: Lesson 14, narrator is guiding pupil through one-to-one correspondence.

Figure 3: Lesson 14, narrator is guiding pupil through counting to demonstrate cardinality.

After the initial lesson animations, Lesson 14 continues with a variety of interactive activities that focus on number identification, number formation, number name recognition, number lines, sorting and counting. The final learning activity is the ebook which recaps what has been learned and acts like a plenary for each *Mathseeds* lesson to consolidate new concepts and skills. The final part of each lesson is a pet hatching animation. Each lesson ends with the hatching of a unique pet that is added to the *Mathseeds* map. This is a highly motivational element for children who look forward to seeing which animal will be next. These hatching pets act as both a reward for lesson completion and they also encourage children to proceed to the next lesson in the programme.

In addition to the core lessons, the *Driving Test* area of the programme offers a wide range of tests that assess skills and knowledge in number, operations, patterns, measurement, geometry and data. While the *Number Facts* area of the programme focuses on building fluency with basic facts, this section brings mental arithmetic to life, where pupils can engage in a huge range of fun activities that develop number fact fluency.

Active Engagement

“...behavioural engagement encompasses the idea of active participation and involvement in academic and social activities, and is considered crucial for the achievement of positive academic outcomes.” (Attard, 2012, p.10)

Research indicates that mathematical engagement occurs when pupils *enjoy* the subject of mathematics, *value* their mathematics learning and see *the relevance* of it in their lives. The ability to *make connections* between the mathematics that is taught in class and the mathematics that is applied in the outside world is crucial (Attard, 2012; Roschelle, Pea, Hoadley, Gordin & Means, 2000). Similarly, Willis (2014) has stated that, “Relevance increases engagement and reduces boredom when pupils recognise instruction as related to their interests...” (p.30). It is engagement, rather than memorisation tasks that activates more pleasure structures in the brain (Poldrack, Clark, Pare-Blagoev, Shohamy, Crespo Moyano, Myers & Gluck, 2001).

In recognising the importance of this research, the lessons and *Playroom* activities encourage pupils to make connections between their experience of the real world and mathematical thinking. Anthony & Walshaw (2009) in their research commented how

“Making connections across mathematical topics is important for developing conceptual understanding... When students find they can use mathematics as a tool for solving significant problems in their everyday lives, they begin to view the subject as relevant and interesting.” (p.156)

New skills and concepts are taught in a context that is relevant, familiar and of interest to most young children. From choosing the correct bus as it drives by, to feeding birds the correct number of worms in a bird café, to getting an astronaut back to his rocket ship, the *Mathseeds* activities bring mathematical concepts to life. And with more than 350 different activities, pupils are always seeing content that is new and interesting. For pupils working through the programme, the *Mathseeds* lessons and activities are all set in a non-threatening environment that supports risk taking and rewards perseverance.

“Mathematics is not only taught because it is useful. It should be a source of delight and wonder, offering pupils intellectual excitement and an appreciation of its essential creativity.”

National Curriculum, 1989



Instructional Formats

“Engage students by utilising a variety of rich and challenging tasks that allow students time and opportunities to make decisions, and which use a variety of forms of representation.” (Sullivan, 2011, p.26)

At the core of *Mathseeds* are the instructional movies and interactive activities that make up the beginning of each lesson. Both the videos and activities have been purposely designed to encourage active learning rather than what Roschelle & his colleagues referred to as the “passive role of receiving information” (2000, p.79). Evidence supports the belief that pupils learn best when they are provided with short sessions, quick instructional pace and time to process new information (Fuchs and Fuchs, 2001; Jensen, 2005). As shown in *Figure 4*, Jensen (2005) recommends 5–8 minutes direct instruction for early primary school pupils. The *Mathseeds* instructional video sequence is interspersed with short, interactive activities which serve as practise and consolidation, as well as a method for keeping pupils focussed.

Guidelines for Direct Instruction of New Content

Year level	Appropriate Amount of Direct Instruction
R-2	5–8 minutes
Years 3–5	8–12 minutes
Years 6–8	12–15 minutes
Years 9–12	12–15 minutes
Adult learners	15–18 minutes

Figure 4: Jensen (2005) identified appropriate durations for direct instruction for children.

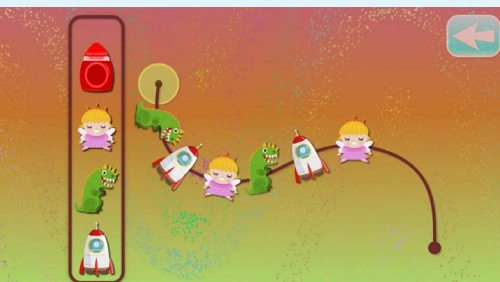


Figure 5: Playroom, pupils are asked to continue simple patterns.

The *Mathseeds Playroom* contains several activities that have been designed for young children. They are a combination of open-ended tasks, such as stamping shapes to create a picture, or specific tasks such as popping balloons on a 0–9 number line. *Figures 5–8* show these learning activities in action. The activities take into consideration the short concentration spans of young children, but several activities loop for as long as the child wants to engage and play.



Figure 6: Playroom, pupils are playing with cardinality.



Figure 7: Playroom, pupils are exploring measurement.



Figure 8: Playroom, pupils are identifying numbers and coloring.



“Representations are key tools for mathematical learning, particularly the use of linked multiple representations. Often conceptual understanding comes through recognising representations and the connections between them.”

**Anne Watson, Oxford University;
Keith Jones, University of
Southampton; Dave Pratt,
Institute of Education; 2016**

Interactive activities are by their nature, more compelling than paper and pencil activities. A study by Moyer, Niezgoda & Stanley (2005) revealed, the high level of creativity and complexity demonstrated by kindergarten pupils using virtual manipulatives and software, as opposed to concrete materials. *Mathseeds* lessons use short and varied activities to maintain pupil interest and regular rewards to boost motivation. The activities are playful so that pupils see them as an extension of how they play – and this means pupils are more likely to be fully involved and immersed in the activity, which also helps to build stronger connections and boost memory retention of new skills. Many of the *Mathseeds* instructional movies end with a song. This acts as an additional way for pupils to remember mathematical concepts in a fun and engaging way (Hayes, 2009; Jensen 2005).

One important feature of the *Mathseeds* instructional format is that on completion of every activity, the pupil receives immediate encouragement, feedback and error correction in a non-threatening way. Feedback in the early stages of learning is essential for keeping pupils on track and focussed (Garnett 2005; Griffith & Burns 2012; Jensen, 2005). Hattie and Timperley (2007) reveal that “... the most effective forms of feedback provide cues or reinforcement to learners... in the form of video-, audio-, or computer-assisted instructional feedback...” (p.84). This view is shared by Roschelle et al. (2000) who confirm that computer technology encourages rapid interaction and feedback. Pupils who receive this type of prompt feedback are more likely to be motivated to continue (Fuchs & Fuchs, 2001).

The interactive activities that follow each lesson give pupils vital opportunities to review, revise and repeat new skills (Jensen, 2005). They allow pupils to build on their knowledge and see the links between mathematical ideas, as evidenced as important by Anthony & Walshaw (2009). In keeping with the concept of a spiral curriculum (Bruner 1960), the *Mathseeds* programme is structured so that ideas introduced in early lessons are later re-visited at a more advanced level. Mathematical vocabulary is introduced early in order to prepare pupils for future, more complex learning (Anthony & Walshaw, 2009; Jensen, 2005).





Learning Styles and Multiple Intelligences

“How students process information – how well they learn and how well they retain knowledge – is directly related to the learning style of the individual”

(Manner, 2001, p.390)

Much has been written regarding individual learning styles and multiple intelligences; their importance and implications for learning (Adams 2000; Bloom 1956, Clausen-May, 2005; Green 1999; Tiberius & Tipping, 1990). The work of Gardner (2011) identifies the variety of intelligences that pupils apply in learning situations, highlighting the fact that not all children learn in the same way and require programmes that reflect their different approaches to learning (Adams, 2000). The scope of Gardner’s work on discrete multiple intelligences is demonstrated by *Figure 9*. Educators can engage with the widest possible audience where they design activities that utilise this broad range of intelligences for their pupils.

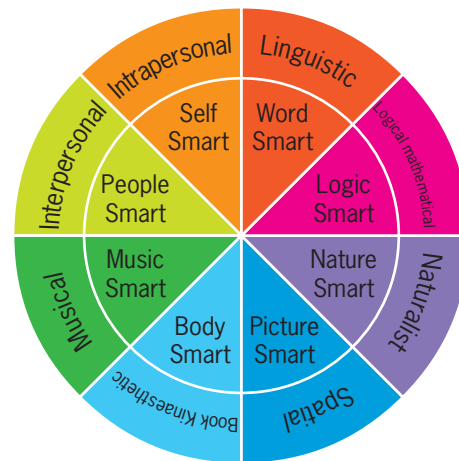


Figure 9: Howard Gardner’s Multiple Intelligences

Mathseeds is designed to appeal to different learning styles and multiple intelligences. The programme’s content and variety allow all pupils the opportunity to engage in mathematical learning. The following examples illustrate how *Mathseeds* caters for multiple intelligences.

- **Logical/Mathematical**

Mathseeds appeals to those who think logically. There are opportunities within the programme for pupils to calculate answers, solve problems with numbers, draw conclusions, explore the relationships between numbers, shapes and statistical data, work with different representations of numbers, and gather and interpret information.

- **Verbal/Linguistic**

The programme offers opportunities for seeing, saying, counting, reading and writing numbers. The *Mathseeds Playroom* also offers opportunities for young children to hear and sing along with familiar nursery rhymes that reinforce counting and simple mathematical concepts such as days of the week.

“Pluralization achieves two important goals: when a topic is taught in multiple ways, one reaches more students. Additionally, the multiple modes of delivery convey what it means to understand something well. When one has a thorough understanding of a topic, one can typically think of it in several ways, thereby making use of one’s multiple intelligences.”


Howard Gardner, Developmental Psychologist, Harvard Professor



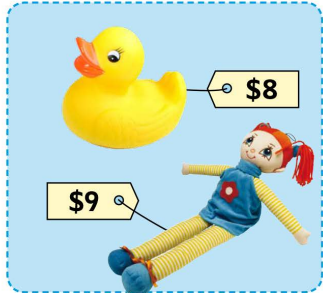
Throughout the programme, children are encouraged to listen and follow instructions. There are opportunities to read and comprehend word problems and explore ways of converting problems to algebraic expressions. *Mathseeds* characters expose pupils to new mathematical expressions and assist them to explore mathematical vocabulary. Research indicates that these aspects should be modelled in order to enhance pupils' understanding (Runesson, 2005). At the end of each lesson, pupils can read ebooks that consolidate new concepts. The texts are professionally narrated which provide a model for the child's own reading fluency. *Figure 10* shows the layout and content for the ebook *Near Doubles* for Lesson 91.

“Good manipulatives are those that are meaningful to the learner, provide control and flexibility to the learner, have characteristics that mirror, or are consistent with cognitive and mathematical structures, and assist the learner in making connections between various pieces and types of knowledge.”

Douglas H. Clements, Distinguished Professor, University at Buffalo



Some numbers are near doubles.
If you know that $8 + 8 = 16$, you
4 can work out the total for $8 + 9$.



How much for the doll and duck?

5

Figure 10: Lesson 91, ebook, *Near doubles*.

- **Visual/Spatial**

The *Mathseeds* programme features high quality, colourful animations that have been designed to appeal to the visual learner. The onscreen graphics are bold, clear and engaging. Lesson progression is mapped in a fun and unique way. Pupils are taken to a range of virtual habitats. Stepping stones mark progress through each habitat and on completion of each lesson, pupils move forward to the next stepping stone. This creates a very powerful and visual way of helping pupils see the progress they are making and ensures that they stay motivated towards their goals. Making progress visible to pupils is articulated in research as being a key goal (Adams & Hamm, 2014; Marzano, 2007; McLennan and Peel, 2008).

In addition, each *Mathseeds* lesson is accompanied by an ebook, created from quality, full colour illustrations. The programme also has accompanying posters and worksheets to consolidate learning and increase information processing.

- **Bodily/Kinaesthetic**

Mathseeds offers kinaesthetic learners the ability to engage their senses and create an experience that goes beyond simply learning by rote which Clausen-May (2005) identifies as crucial. Early number concepts are taught in a very visual and kinaesthetic way and encourage pupils to see numbers as wholes. The first *Mathseeds* song ‘There is only one of me’ encourages the pupil to see and *feel* that they have *only* one nose, *one* face, *one* mouth etc.

Bobis (2008) in her research identifies how virtual manipulatives can assist pupils with number sense and spatial thinking. In *Mathseeds* pupils are encouraged to subitise early on and the presence of dominoes, dots, and various other engaging items to count are available for *all* pupils to use – not just the kinaesthetic learners. Research indicates that when given the appropriate materials, pupils can mentally combine and partition numbers. This is an important skill prior to the introduction of addition and subtraction (Bobis, 2008).

Early addition lessons physically show the main character joining two distinct sub-groups together to form one group, or total. Only when this concept of addition is in place does the programme present addition in the form of a simple number sentence and eventually as a formal algorithm. *Figures 11–13* demonstrate the sequential building of this conceptual knowledge.



Figure 11: Lesson 24, characters are exploring two distinct groups and joining them together to find the total.



Figure 12: Lesson 51, characters are adding and locating the final counted numeral as the total on a number line.

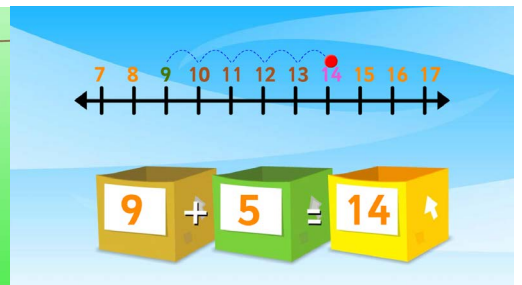


Figure 13: Lesson 65, characters are creating formal number sentences from pictorial representations.

Similarly, subtraction is taught through more than one approach. Pupils physically take items away from the main group when learning how to subtract. They also learn to cover items up, and eventually progress to counting back along a number line, using subtraction number sentences and finally formal algorithms. This multi-level and kinaesthetic approach allows pupils to understand *why* a method works, rather than *how* to just solve a problem (Clausen-May, 2005).

“Play and learning maths do not have to be mutually exclusive events. Play and games can give young children opportunities to learn and develop foundational math skills”

**Dr Geetha Ramani & Sarah Eason,
University of Maryland, 2016**

- **Musical**

Mathseeds is full of playful songs that act as mnemonics to aid memory and consolidate new concepts. The songs are popular amongst children and perfect for those who have sensitivity to music. The *Mathseeds Playroom* has a number of traditional nursery rhymes and familiar songs that reinforce simple counting skills and other mathematical ideas.

Aspects of rhythm are also used to teach mathematical concepts such as patterning. According to Mulligan (2010), “an awareness of mathematical pattern and structure is both critical and salient to mathematical development” (p.47). In *Mathseeds* students are encouraged to participate in simple dances, led by the onscreen characters, to demonstrate the idea of repeating patterns. *Figure 14* is an example of one such song from Lesson 66 about fractions.



Figure 14: Lesson 66, characters singing a fraction song about quarters.

- **Interpersonal/Intrapersonal**

The *Mathseeds* programme can be used in a variety of ways to promote interpersonal and intrapersonal skills. It can be used with a whole class or for a focussed group lesson. It encourages talk and discussion, sharing and group participation. The programme can also be used on an individual basis for pupils who prefer to work alone at their own pace. It allows for thoughtful reflection on individual progress.

Mathseeds lessons encourage pupils to think about how they use mathematics outside the lesson. This provides opportunities for pupils to draw on their own experiences and construct their understandings of the real world (Perry, 2000; Tiberius & Tipping; 1990). In *Mathseeds* the onscreen characters model how to solve problems through discussion and rationalising. They effectively teach pupils how to monitor the problem solving process and demonstrate for pupils how a collaborative atmosphere enhances learning.



Motivational Elements

When addressing the issue of how to interest and engage pupils, Sullivan and McDonough (2007) refer to the pupil's "willingness to persist" (p.698). This "willingness" is the motivation required for pupils to complete learning activities. Motivation plays a key role in learning (Gagne & Deci, 2005; Jensen 2005; Rodionov & Dedovets, 2011; Sullivan & McDonough, 2007; Taylor & Adelman, 1999). Intrinsic motivation rewards pupils purely for participating in the activity itself, whereas extrinsic motivation is derived from gaining awards such as certificates or verbal rewards (Gagne & Deci, 2005; Ryan & Deci, 2000). These important, positive rewards impact on pupil motivation (Griffith & Burns, 2012; Jensen 2005). *Mathseeds* seeks to provide both intrinsic and extrinsic motivational rewards in order to produce total satisfaction.

Rewards reinforce existing learning and encourage new learning to occur. The brain responds favourably to rewards, the potential for rewards (prediction) and to unexpected rewards (surprise). It releases a sudden burst of dopamine that makes the pupil feel good and motivated to continue with the task (Bear, Connors & Paradiso, 2007; Jensen, 2005)

The *Mathseeds* programme rewards pupils with a cute pet that hatches from an acorn at the end of each lesson sequence. The first time this happens is an unexpected surprise for the pupil. After subsequent lessons the pupil knows it will happen (prediction) but they still have the element of surprise as they do not know what each pet will be until it hatches.

According to Edward de Bono, "Humour is by far the most significant activity of the human brain" (de Bono cited by Griffith and Burns, 2012, p.61). The *Mathseeds* programme actively motivates pupils through its elements of humour and playfulness. Each hatching pet has its own unique character that pupils can enjoy. In addition, the five key characters are role models for students; exploring new mathematical challenges and having fun whilst they learn.

Learning is an ongoing, dynamic process and the learning environment must continuously change to reflect this (Taylor & Adelman, 1999). The *Mathseeds* programme moves through different locations, with regard to the lessons and reward maps. The key characters remain the same but they present the lessons intermittently to maintain pupil interest. The huge range of interactive activities are uniquely written and animated in different styles to prevent pupils from becoming bored and demotivated.

According to Taylor & Adelman (1999), "One of the most powerful factors for keeping a person on task is the expectation of feeling some sense of satisfaction when the task is completed' (p.266). *Mathseeds* rewards pupils with golden acorns at the completion of each lesson and activity. These get banked and can later be spent on clothes for the pupil's avatar (online character) or furniture for their personal tree house.

After the completion of five lessons, pupils participate in an online quiz. If they pass, their efforts are rewarded with a printable certificate that has their name on and will be either a gold, silver or bronze award. Providing a representation of a very personal accomplishment can be a valuable motivator to improve pupil achievement (Marzano, Pickering & Pollock, 2001). The range of rewards that *Mathseeds* offers pupils actively encourages them to engage with the programme, to explore it, to learn from it, and to value their progress.

"In order to become capable and strategic learners in mathematics, pupils need to have confidence in their own ability and self-identity as learners of mathematics. Strategies that promote inclusiveness, deep thinking, and ownership, can have a powerful effect on building pupils' mathematics skills."

Chris Kyriacou, Professor in Educational Psychology, University of York

"Raising pupil attainment in mathematics is one of those things that is so easy to say, yet is so difficult to achieve, and sustain. In short, it is an enduring challenge in most mathematics classrooms."

Sue Gifford and Penny Latham, Everyone Learning Project, 2013



Assessment & Reporting

Assessment is necessary to monitor progress, to identify strengths and weaknesses, and to inform further instruction. *Mathseeds* weaves pupil-facing assessment seamlessly throughout the program. Detailed reports keep teachers informed as to where individual pupils are in reaching their goals. This enables teachers and school leadership staff to make informed judgments about pupil understanding against national standards and benchmarks.

Mathseeds includes both summative and formative assessment opportunities. These assessments present pupils with multiple avenues to show their knowledge and have distinct structures to cater for a wide range of pupils.

Mathseeds provides multiple opportunities for informal assessment through the range of interactive activity types. These increase in difficulty by gradually removing supports like reminders and visual manipulatives as pupils demonstrate competency. The gradual removal of scaffolds reduces the potential for anxiety and boosts pupil success. For pupils, interactive activities offer immediate feedback and the ability to correct errors. These are critical to ensure pupils continually self-monitor their understanding.

Mathseeds End-of-Map Quizzes and Driving Tests provide formal assessment opportunities. At the completion of every five lessons, pupils complete a 15-question assessment quiz. This assesses pupil understanding of the content covered in the latest map with results appearing in teacher reports. The Driving tests are 10-question tests that assess pupil knowledge in essential mathematics skills. These assessments have responsive feedback that requires pupils to redo questions answered incorrectly. This allows pupils to critically evaluate incorrect responses to reinforce correct mathematical thinking.

Another assessment component can be found in the teacher toolkit, where teachers can choose from a range of printable assessment tasks that can be used with individual pupils, groups or the whole class. This provides teachers with rich assessment data to aid both in reporting and to inform targeted teaching.

"I am more and more convinced of a need for planned consolidation, so that after every mathematical task, whether it was a practice exercise, a problem-solving activity, a game, or whatever, there needs to be some kind of interaction that reviews the core mathematical idea, together with its language, and its representations, and focuses on how it arose and how it might be recognised in future."

Anne Watson, Oxford University, 2014

“One of the chief benefits of mobile devices is that they enable learning anywhere, anytime. This allows a shift away from the industrial era model where the classroom is the central place of learning driven by the teacher and limited to instruction within the school day. In deploying mobile devices, the teacher is no longer at the centre of the learning process and the instructional time can transcend the school day.”

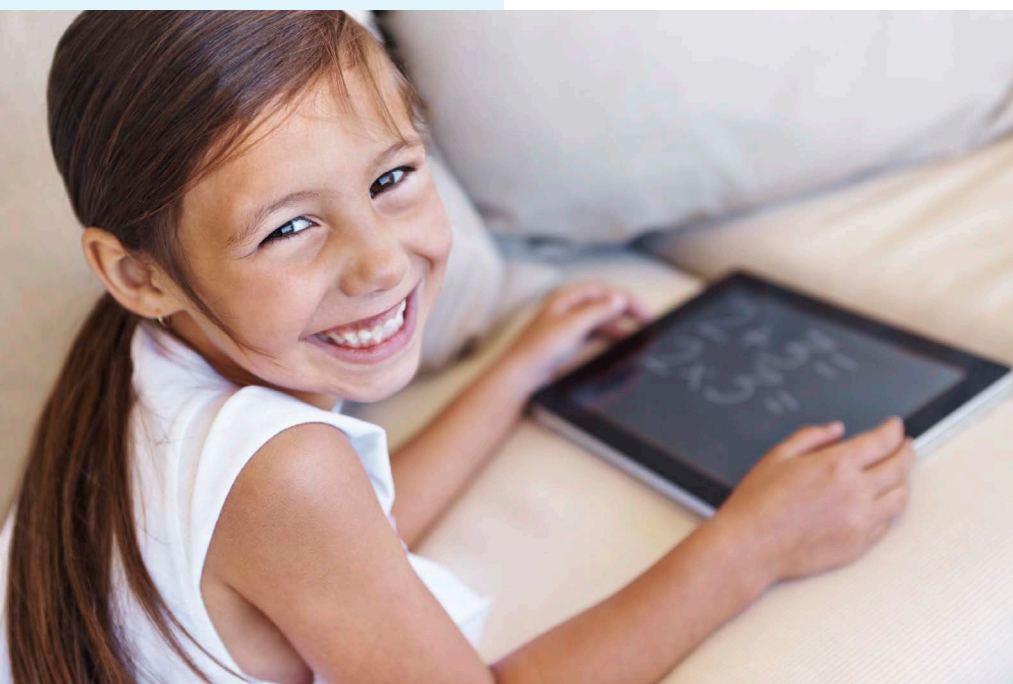
Dr Kristy Goodwin, Institute of Early Childhood, Macquarie University, 2012

Technology

As technology permeates all aspects of interactions, it has become “an ubiquitous tool for teaching and learning” (Li & Ma, 2010, p.215).

Cheung & Slavin (2013) identify that as technology permeates 21st century living, the question for teachers shouldn't be whether to use educational technology but rather what applications ensure it is incorporated in the best way for pupils (p. 102). Technology that enables the manipulation of virtual objects is powerful (Hoyles & Noss, 2009), as are regenerative question designs that afford endless practise opportunities. By its design, the *Mathseeds* programme takes advantage of the inherent benefits of computer technology. The programme allows children to manipulate objects in a variety of ways, to experiment without fear of failure and test out their new skills through a range of practice opportunities. Accessible on desktop and mobile devices it bridges the home and school divide working to connect family and school communities in the learning process.

Research indicates the most powerful potential for tools are where meaningful interactions operate alongside sound teaching and learning strategies (Coley, Cradler & Engel, 2000) and guided support (Moyer et al., 2005). *Mathseeds* is an innovative interactive teaching and learning resource designed by educators to connect pupils to the key concepts of number sense. In teaching and learning sequences, pupils play with virtual manipulatives in short, focused sequences. This teaching is always linked to content in the lesson that follows and is a scaffold to provide guided support for activities within the lesson sequence.



Conclusion

Mathseeds is an interactive Web-based programme that incorporates a huge range of highly structured, effective, research-based activities. It combines rigorous learning with high interest level activities, taking into consideration the needs, learning styles and future direction of learners in the 21st century. *Mathseeds* has been built on best practise in pedagogical research alongside core curriculum initiatives, creating a programme that is both educationally sound and highly motivating. *Mathseeds* lessons provide an engaging environment for young children who learn best through play. The instructional elements and interactive activities are set in contexts that are meaningful and relevant. The programme offers a range of age-appropriate rewards that actively encourage pupils to engage with the programme, to explore it, to learn from it, and to value their progress.

Mathseeds is designed to seamlessly connect learning between school and home, making learning possible anywhere and easily accessible on different devices. Its comprehensive assessment and reporting procedures allow pupils, parents and teachers to receive instant feedback on progress and achievements made. Written by experts with over 25 years of experience in creating high-quality educational resources, *Mathseeds* has been carefully designed to maximise pupil learning and to equip pupils with the strongest foundation possible to achieve lifelong mathematical success.



References

- Adams, T.L. (2000). Helping children learn mathematics through multiple intelligences and standards for school mathematics. *Childhood Education, 77*, (2), 86–94.
- Adams, D. & Hamm, M. (2014). *Teaching math, science and technology in schools today: Guidelines for engaging both eager and reluctant learners*. Plymouth: Rowman & Littlefield Education.
- Anthony, G., & Walshaw, M. (2009). Characteristics of effective teaching of mathematics: A view from the West. *Journal of Mathematics Education, 2* (2), 147–164.
- Askew, M. (2016) *Transforming primary mathematics: understanding classroom tasks, tools and talk*. Routledge: New York.
- Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom, 17* (1), 9–13.
- Back, J., Sayers, J. & Andrews, P. (2013) *The development of foundational number sense in England and Hungary: a case study comparison*. Conference Proceedings: CERME 2013.
- Bear, M., Connors, B. & Paradiso, M. (2001). *Neuroscience. Exploring the brain*. Baltimore, MD: Lippincott Williams & Wilkins.
- Bloom, B. (1956). *Taxonomy of educational objectives*. New York: David Mackay.
- Bobis, J. (2008). Early spatial thinking and the development of number sense. *Australian Primary Mathematics Classroom, 13* (3), 4–9.
- Bruner, J. (1960). *The Process of Education*. Cambridge: Harvard University Press.
- Cain, C., Doggett, M., Faulkner, V., & Hale, C. (2007). *The components of number sense*. Raleigh, NC: NC Math Foundations Training, Exceptional Children's Division of the North Carolina Department of Public Instruction (NCDPI).
- Cheung, A. C. K. & Slavin, R. E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K–12 classrooms: A meta-analysis. *Educational Research Review, 9*, 88–113.
- Clausen-May, T. (2005). *Teaching maths to pupils with different learning styles*. London: Paul Chapman Publishing.
- Clements, D. & Sarama, J. (2009). *Learning and teaching early maths: The learning trajectories approach*. New York: Routledge.
- Coley, R., Cradleer, J. & Engel, P.K. (2000). *Computers and the classroom: The status of technology in US schools*. Princeton: Policy Information Center, Educational Testing Service.
- Cross, C.T., Woods, T.A. & Schweingruber, H. (Eds.) *Mathematics learning in early childhood: Paths toward excellence and equity*. Washington: National Academy Press.
- Department of Education (2015) *National curriculum assessments at key stage 2 in England (provisional)*. Sheffield: Education Data Division, Department of Education. Accessed from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456343/SFR30_2015_text.pdf

- Department of Education (2016) *Educational Excellence Everywhere*. London: Williams Lea Group on behalf of Her Majesty's Stationery Office. Accessed from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/508550/Educational_excellence_everywhere__print_ready_.pdf
- Edelson, D. C., & Joseph, D. M. (2001). *Motivating educational psychology interactive*. Valdosta, GA: Valdosta State University.
- Earnest, P. (2010). Add it up: Why teach mathematics? *Professional Educator*, 9 (2), 44–47.
- Faulkner, V. N. (2009). The components of number sense: An instructional model for teachers. *Teaching Exceptional Children*, 41 (5), 24–30.
- Fredricks, J., McColskey, W., Meli, J., Mordica, J., Montrosse, B., and Mooney, K. (2011). *Measuring student engagement in upper elementary through high school: a description of 21 instruments*. (Issues & Answers Report, REL 2011–No. 098). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southeast.
- Fuchs, L.S., & Fuchs, D. (2001). Principles for the prevention and intervention of mathematics difficulties. *Learning Disabilities Research & Practise*, 16 (2), 85–95.
- Gagne, M. & Deci, E.L. (2005). Self-determination theory and work motivation. *Journal of Organized Behavior*, 26, 331–362.
- Gardner, H. (2011). *Frames of mind: The theory of multiple intelligences* (3rd ed.). New York: Basic Books.
- Garnett, S. (2005). *Using brainpower in the classroom: five steps to accelerate learning*. London: Routledge.
- Gersten, R. & Chard, D.J. (1999). Number sense: Rethinking math instruction for students with learning disabilities. *The Journal of Special Education*, 33, 18–28.
- Gifford, S. & Latham, P. (2013) Removing the glass ceiling on mathematical achievement in primary classrooms: Engaging all pupils in mathematical learning. *Mathematics Teaching* 232, pp. 31–34.
- Green, F.E. (1999). Brain and learning research: Implications for meeting the needs of diverse learners. *Education*, 111 (4), 682–687.
- Griffith, A. & Burns, M. (2012). *Outstanding teaching: engaging learners*. Wales: Crown House Publishing.
- Hayes, O.C. (2009). *The use of melodic and rhythmic mnemonics to improve memory and recall in elementary students in the content areas*. Unpublished Ph.D., Dominican University of California.
- Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77 (1), 81–112.
- Highfield, K. & Mulligan, J. (2007). The role of dynamic interactive technological tools in preschoolers' mathematical patterning. In Watson, J. & Beswick, K. (Eds.), *Mathematics: Essential research, essential practise* (pp.372–381). Adelaide: Mathematics Education Research Group of Australasia Inc.
- House, J. D. (2006). Mathematics beliefs and achievement of elementary school students in Japan and the United States: Results from the third international mathematics and science study. *The Journal of Genetic Psychology*, 167 (1), 31–45.

- Howell, S. & Kemp, C. (2009). An international perspective of early number sense: Identifying components predictive of difficulties in early mathematics achievement. *Australian Journal of Learning Disabilities*, 11 (4), 197–207.
- Hoyles, C. & Noss, R. (2009). The technological mediation of mathematics and its learning. *Human Development*, 52, 129–147.
- Jensen, E. (2005). *Teaching with the brain in mind*. Alexandria: Association for Supervision & Curriculum Development.
- Jordan, N.C., Glutting, J. & Ramineni, C. (2009). The importance of number sense to mathematics achievement in first and third grades. *Learning and Individual Differences*, 20, 82–88.
- Jordan, N.C., Kaplan, N., Locuniak, M.N. & Ramineni, C. (2007). Predicting first-grade math achievement from developmental number sense trajectories. *Learning Disabilities Research & Practise*, 22 (1), 36–46.
- Kennedy, J., Lyons, T., Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science*, 6 (2), 34-46.
- Klibanoff, R.S., Levine, S.C., Huttenlocher, J., Vasilyeva, M. & Hedges, L.V. (2006). Preschool children’s mathematical knowledge: The effect of teacher “Math Talk”. *Developmental Psychology*, 42 (1), 59–69.
- Li, Q. & Ma, X. (2010). A meta-analysis of the effect of computer technology on school students’ mathematics learning. *Educational Psychology Review*, 22 (3), 215–243.
- Manner, B. (2001). Learning styles and multiple intelligences in students. *Journal of College Science Teaching*, 30 (6), 390–393.
- Marzano, R.J. (2007). *The art and science of teaching: A comprehensive framework for effective instruction*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.
- McLennan, B. & Peel, K. (2008). Motivational pedagogy: Locking in the learning. *The Australian Education Leader*, 30 (1), 22–27.
- Moyer, P., Niezgodá, D. & Stanley, M. (2005). Young children’s use of virtual manipulatives and other forms of mathematical representation. In W. Masalski & P. Elliott (eds.), *Technology-supported mathematics learning environments* (pp. 17–34). Reston: NCTM.
- Mulligan, J.T. (2010). Reconceptualising early mathematics learning. In C. Glascodine and K. Hoad (Eds.) *Teaching mathematics? Make it count. Proceedings of the Annual Conference of the Australian Council for Educational Research* (pp. 47–52). Camberwell: ACER.
- National Curriculum Council (1989). *Mathematics: non-statutory guidance*. York: National Curriculum Council.
- National Numeracy: For everyone, for life (2016) *What is the issue?* Accessed from <https://www.nationalnumeracy.org.uk/>
- Perry, B. (2000). *Early childhood numeracy*. Australian Association of Mathematics Teachers. Retrieved February 2, 2015 from www.aamt.edu.au/content/download/1252/25269/file/perry.pdf

- Planty, M., Hussar, W., Snyder, T., Kena, G., Kewal Ramani, A., Kemp, J., Bianco, K., Dinkes, R. (2009). *The Condition of Education 2009*. United States: National Center for Educational Statistics.
- Poldrack, R.A., Clark, J., Pare-Blagoev, E.J., Shohamy, D., Creso Moyano, J., Myers, C. & Gluck, M.A. (2001). Interactive memory systems in the human brain. *Nature*, 414, 546–550.
- Ramani, G. B. & Eason, S. H. (2015) It all adds up: learning early math through play and games. *Phi Delta Kappan*, 96 (8), pp. 27–32.
- Rays, R.E., Lindquist, M., Lambdin, D.V. & Smith, N.L. (2012). *Helping children learn mathematics* (10th ed.). United States: John Wiley & Sons.
- Renninger, K.A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone and J. M. Harackiewicz (Eds.) *Intrinsic motivation: Controversies and new directions* (pp. 373–404). San Diego, CA: Academic Press.
- Rodionov, M. & Dedovets, Z. (2011). Increasing learner's level of motivation in mathematics education through the use of uncomplicated situations. *Literacy Information and Computer Education Journal*, 2 (2), 366–371.
- Roschelle, J.M., Pea, R.D., Hoadley, C.M., Gordin, D.N. & Means, B.M. (2000). Changing how and what children learn in school with computer-based technologies. *The Future of Children: Children and Computer Technology*, 10 (2), 76–101.
- Runesson, U. (2005). Beyond discourse and interaction. Variation: A critical aspect for teaching and learning mathematics. *Cambridge Journal of Education*, 35 (1), 69–87.
- Ryan, M. & Deci, E.L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25, 54–67.
- Sullivan, P. (2011). *Teaching mathematics using research-informed strategies*. Camberwell, Vic: ACER Press.
- Stephens, M. (2011). *Engagement in mathematics: defining the challenge and promoting good practices*. Research Monograph 9, Melbourne: Department of Education and Early Childhood Development.
- Sullivan, P. & McDonough, A. (2007). Eliciting positive student motivation for learning mathematics. *Mathematics: Essential Research, Essential Practise: 30th Annual Conference of the Mathematics Education Research Group of Australasia*, 2, 698–707.
- Taylor, L. & Adelman, H. (1999). Personalizing classroom instruction to account for motivational and developmental factors. *Reading & Writing Quarterly*, 15, 255–276.
- Tiberius, R. & Tipping, J. (1990). *Twelve principles of effective teaching and learning for which there is substantial empirical support*. Toronto: University of Toronto.
- Willis, J. (2014). Neuroscience reveals that boredom hurts: students who seem to wilfully defy admonishments to focus on their work may not be doing so intentionally but rather as a normal, age-appropriate brain reaction. *Phi Delta Kappan*. 95 (8), 28–32.

Turvill, R. (2016) *Number sense as a sorting mechanism in primary mathematics education*. CERME 9—Ninth Congress of the European Society for Research in Mathematics Education, Prague, Czech Republic. pp. 1658–1663.

Watson, A., Jones, K., Pratt, D. (2016). *Key ideas in teaching mathematics*. London: Nuffield Foundation. Accessed from <http://www.nuffieldfoundation.org/key-ideas-teaching-mathematics>

Watson, A. (2014). Consolidation. *Mathematics Teaching* 243, pp. 19–22.