

Approaches to Teaching Numeracy For All

Introduction

All the evidence suggests it is almost impossible to overestimate the importance of children's early experiences with number, pattern, shape and space, and the language associated with those: those working with pre-school and primary children in formal or informal settings, at home or in the community, have a very important influence on what children can later do, and on their attitudes to these areas (see for example <https://www.gov.uk/government/news/graham-allen-launches-second-report-on-early-intervention>). However, the international evidence on pre-school experiences is largely at a high level, rather than focused on specifics (Sim et al., 2018), leading to some debate about what details are most important. Further, existing evidence has to be used carefully, since 'primary education' and 'pre-school' happen at different ages and development stages in different countries. Many of the most successful in international terms have two or more years' pre-school, largely informal, provision before children begin school at age seven, whereas in others, for example the UK, children can start formal schooling in the September after they turn four, so what we know about teaching 5-7 year olds varies according to local provision.

We do, know, though (Sim et al., 2018), that parents, families and friends have a **very important** role in talking with children, and helping them to develop everyday skills. Whenever community provision for young children begins, it is important that it builds on the knowledge and skills children bring with them from home. Most evidence supports fairly informal, play-centred provision at first but with knowledgeable teaching that focuses on deliberate development of opportunities to build up social and practical skills, experience listening and talk, observation and discussion of the environment, and early work to recognise and enjoy the role of sounds, letters, words and numbers. They benefit from songs, stories and rhymes that are part of their cultural heritage, and from talking about those. If there are books available, they can learn better about the functions of the written word, and patterns of following text, turning pages, and links with the spoken word. These experiences are all central foundations to children's later learning and cannot be rushed (OECD, 2018). Only when children have those basic tools, are they ready to take advantage of more formal learning. In situations where pre-school experiences have been mixed, or there is conflict, these are the important areas on which to focus initially, and further specifics are given in the pre-school section of 'pedagogies to support numeracy for all'. Links to the international research underpinning recommended provision for children before they start formal schooling include also <http://www.earlyyearsatters.co.uk/our-services/school-and-nursery-support/early-years-adviser/birth-to-three-matters/> and <https://foundationyears.org.uk>.

We first outline the evidence about general approaches to teaching young children, then address what we know about productive approaches for pre-school development of numeracy, and finally, for early primary numeracy. More specific details of teaching approaches are given in the 'pedagogy' section elsewhere.

Approaches to teaching young children: general

What makes excellent teaching? Research shows that a good sense of humour and teaching that actively involves children in doing, talking about and making meaning of their learning are key characteristics of great teaching. This section considers evidence about general approaches to teaching in pre-school settings and primary schools. In pre-school settings children benefit from much more informal approaches, as above, but many of the same high-level considerations apply. The next section considers approaches to teaching numeracy and mathematics in particular. Much of the research quoted was done in England, but is consistent with that found elsewhere, and the detailed commentary relies on the author's experiences in a variety of places where the usual primary and pre-primary classes are large (sometimes up to 150), with very few resources.

An important report is '*Exploring Effective Pedagogy in Primary Schools: Evidence from Research*', written by Professor Iram Siraj and Dr Brenda Taggart of London's Institute of Education and published by Pearson and available at <https://www.pearson.com/uk/educators/schools/making-an-impact/research-summaries/exploring-effective-pedagogy-in-primary-schools.html>. It uses data from the EPPSE (Effective Pre-school, Primary, and Secondary Education) study, which monitored the academic attainment and social and behaviour development of more than 3,000 children from the age of three to 16, in over 80 schools in England, to identify the characteristics of "excellent," "good," and "poor" school teachers. Its findings are consistent with a large range of international evidence from a variety of contexts.

Below, we summarise the main messages and expand them to take account of other evidence and teaching situations that might be more demanding than those found in the primary schools on which the report was based. Siraj and Taggart suggest that the characteristics of excellent classrooms are:

- **Organisation** - Teachers prepare their resources and teaching ahead of time, and make productive use of classroom time by use of good pace and ensuring that every second of their lessons count. In pre-primary just as much preparation is needed – but for children to work much more informally for much of the time. Adults need to think about opportunities they are providing for children to play and talk in the ways listed above, for them to join in songs and stories, and if possible, to experience the magic of books and make informal links between spoken and written words, symbols and concepts.
- **Shared objectives** - Although most teachers ensure the learning objectives of the lesson/activity are clear (for example, by writing them on the board), teachers in excellent schools are especially good at making sure the objectives are fully understood. Learners in these classes are very clear about what they are expected to achieve and how much time they have to do it.
- **Homework** – Any homework for slightly older children is clearly linked to what the children are learning, and set to extend and deepen the children's understanding. Homework does not have to be formal and written: it can ask learners to tell each other, or a brother or sister, what they have learned on their walk home, to find examples of the ideas they have worked with in their surroundings, to ask their parents when they use such ideas, to make up some examples of their own that might be shared with the class next day, etc. It is important the teacher then follows up the homework set, in class.

- **Classroom climate** - In excellent classrooms, teacher-learner and learner-learner relationships have warmth and respect. Learners are sociable and cooperative.
- **Behaviour management** - Children in excellent schools rarely need to be disciplined; but where teachers do need to correct behaviour, they use humour or a quiet reminder rather than becoming cross or loud, or intimidating children. This is much harder to achieve with large classes, but clear and consistent (and respectful) classroom rules help. Frequent opportunities for children to discuss ideas and respond to them, and then report to the wider group or class, are important for keeping learners engaged. Where there is space, opportunity to stand up and if possible move around, including using outside spaces where those are available, also helps. For young children, it is especially important there is opportunity for physical movement and developing a sense of what their bodies do.
- **Collaborative learning** - Children in excellent schools spend relatively more time in collaborative learning situations than those in poor schools. 'Collaboration' might be the whole class working with the teacher, it might be children working in pairs or threes, or it might be in slightly large groups: children can manage larger groups as they get older. Children have to *learn* to work in such ways, and to have guidelines for behaviour that is acceptable, so if your class is not used to such approaches, start with pairs and build up from there. It is important that important learning that happens within groups is shared with the whole class, so the teacher must move around and listen carefully to what is happening, where that is possible, so that the whole class can benefit. Younger children can only manage short periods of time focused on a very structured teacher-given task, but longer if the task is more open.
- **Personalised teaching and learning** - Excellent teachers are sensitive to the individual needs of their learners and provide learning materials that are appropriately challenging, and rich and varied in content. That is of course harder to do with large classes than with smaller ones! But good teachers sometimes give learners a choice of which task to do, and at other times they use their good knowledge of learners to choose different tasks for different groups of learners, or ask questions of particular groups of students which give different demands. They do not distance themselves from their learners by staying at their desks, they regularly offer constructive and challenging feedback, and take notice of individual children's behaviour or needs, so far as that is possible.
- **Making links explicit** - Teachers in excellent schools are better able and more consistent in making links to areas both within and outside the specific lesson or learning session. Where possible, they support learners in suggesting those links themselves.
- **Dialogic teaching and learning** - An excellent teacher will progress learning by making sure learners are continually informed by previous work; teachers listen to them actively, rather than just answering, correcting or silencing them. The use of dialogic teaching, where teachers and learners use talk about learning in order to extend learner thinking and understanding, is comparatively well used in maths by excellent teachers. Again, learners have to learn how to take part in that, by building up both their listening and their communication skills.
- **Assessment for learning** - Teachers in excellent schools provide opportunities for learners to reflect on their own learning, to identify what they know and understand and to communicate that with the teacher (by using 'thumbs up', or similar, or using smiley/unhappy faces on their work...). Good teaching then responds to that, and often uses other learners to support next learning. Children benefit from explaining to each

other: as every teacher knows, they have to understand ideas in depth to explain them successfully to someone else!

- **Plenary** - Excellent teachers are more likely to use 'plenaries' in their lessons or sessions to pull ideas together and summarise the intended learning, provide opportunities for further discussion, to explore issues in more depth and to extend work and concepts covered in the lesson or session.

This summary expands one written by Sandy Smith, to consider in particular situations where the teacher might have limited English, there are large classes, little space and few resources: if it will work in such conditions, it will work anywhere! It is based on

Siraj, I. & Taggart, B., with Melhuish, E., Sammons, P. & Sylva, K. (2014). 'Exploring Effective Pedagogy in Primary Schools: Evidence from Research'. London: Pearson.

Approaches to teaching numeracy in pre-school

Numeracy, that is, a confidence and ability to use mathematics, is an essential life skill, yet many young people across the world do not use mathematics well. In most areas of the world, memorising mathematical facts and procedures used to be considered the most important approach for most learners, but now that globally, many jobs use machines to do those tasks, it is increasingly important that learners come to understand and make links with the mathematics they are learning, as well as knowing some basic facts and procedures.

This can be challenging for teachers, as well as for families and other adults, who might not have been brought up to value active meaning-making in education. Older people might feel their authority is being threatened, but the meaning-making approach can, rather, build on the experience and deeper understanding that teachers and family have. If there is something older people do not understand, there is a very important part to play in showing children we none of us know everything -but we can find out. One of the most important approaches is presenting a positive attitude towards mathematics, which we know promotes more effective learning. Learners need to know that they can make sense of mathematics, but it will take effort, and that once they do, it will be very empowering for them – in everyday life, and in employment and opportunities in adult life.

What do we know about effective teaching of numeracy? There have been several reports in the last 20 years, that tell us. Web links to these are given at the end, but they are all research-based, and you can find the details of the research by using the links. Again, although much of the original research on which these reports are based was done in western, wealthy countries (although some references are to evidence from less well-resources areas), it is backed up by experience, including the author's, elsewhere. They are consistent with the messages above, but those are developed for mathematics in particular

The evidence there is suggest that **the best pre-school provision** to ensure later progress in numeracy includes:

- **'Number sense' fostered through an informal play-based curriculum** with outdoor activities, dance, games, construction activities with natural and, if available other resources,

and routines. This would not focus on learning by rote, but on frequent use of numbers in talk, and counting and labelling sets of items with numbers 1 to 10. An effective foundation to ensure progress and prevent later difficulties prioritises number sense with numbers to 10.

- **Language which often uses mathematical words** about number, size, shape, position and location,...and which supports noticing and talk around all sorts of pattern....
- Creative and critical thinking through **rhymes, songs and stories** with and without books
- Creative use of available resources to engage with **puzzles and games**
- Encouragement of a **sense of confidence and curiosity** around such ideas, and of enjoyment and satisfaction in engagement with them (Gifford, 2014).

Approaches to teaching numeracy in lower primary classes

Teaching is more effective when:

- It **builds on the knowledge that learners have**: teachers need to use informal and formal assessment to find out what learners already know and can do, and then plan to build on that.
- It **continues with good pre-school practice** that uses dance, song, rhyme and stories to also develop mathematical ideas.
- It **exposes and discusses common misconceptions** and surprises in mathematics
- It **uses more demanding questions** that go beyond recall of information or procedure, to asking 'what?' and 'how?' to 'why?' and 'how else?' and 'what if?' and also supports learners in asking questions but the mathematics and having those responded to, maybe with 'let's find out: how could we do that?'
- It uses a **mixture of whole-class 'dialogic' teaching** as described above, individual work, and cooperative paired or small group work
- It **values mathematical thinking** in varied and sometimes demanding tasks and problems, rather than just finding answers to routine questions.
- It supports learners in building up experience of a range of increasingly challenging **problems and problem-solving strategies**, so that they come to monitor, reflect on, and communicate those, and understand that 'getting stuck' can be a productive state, from which they learn.
- It supports learners in **making links** ('connections') both within mathematics and with other areas of school and outside-school life, so that they build a rich network of mathematical understanding and understand the potential for their mathematical learning. It builds on the everyday understanding and language learners bring with them to school, to for example, work increasingly and interchangeably with fractions, decimals and percentages, make links between 'fair' and 'unfair' sharing and mathematical ratio and proportion....
- It **works with and solves difficulties**, rather than ignoring or avoiding them
- It helps learners see the **mathematical structure of number so** they have a deep and confident foundation for moving to using number, applying it to real, including spatial, problems, money and time, understanding data, and later on, developing algebraic ways of thinking.
- It **values mathematical language** in increasingly accurate and rigorous ways, developing that through mathematics learning activities that need a variety of ways of

communication. Learning to communicate mathematical ideas in words is very important, and lays foundations for communicating them in writing. Working in pairs or groups gives more children the opportunity to develop their communication skills. As children get older, teachers can and should expect greater accuracy, rigour, and technical vocabulary in what children say. Learners can usefully be asked to show their approaches and thinking in written form, on the board. Teachers should encourage and support them in this, and should also ask other learners to comment constructively on what is written, so that the whole class is involved and learning.

- It supports learners in **recognising what they have learned, how they have learned it**, and also what else they need to learn, so that they are increasingly planning, monitoring and evaluating their learning as they mature.
- It needs teachers to be **talking with learners about their mathematics sense-making**, and listening carefully to what they say, as well as evaluating what they write. That way, the teacher can plan for the next learning needed, and for particular support or challenge needed by some groups of learners, which will vary between different mathematics topics.
- It **uses available, maybe improvised, resources** of all sorts, including any available technology, in creative and appropriate ways, to support such learning. Much deep, and so powerful, understanding of mathematics comes from learners having experience with a variety of ‘representations’ of mathematical ideas, including, where possible, physical representations or ‘manipulatives’ they can handle. The best teachers plan for using these in appropriate ways, so that learners can understand the underlying concepts and eventually will not need the manipulatives. Some key primary manipulatives that teachers can easily make or find, include: number sticks, beads, stones, bottle tops, string ‘number lines’ that learners can peg numbers to, metre rules or string marked in metres.... These ideas, including specific ideas for how to use such resources, are explored in more detail in the ‘pedagogy’ section, since they are about the details of how to make mathematical ideas accessible to learners.
- Where possible, it takes place in an **environment that tells teachers and learners their work is valuable**, and supports their learning. Learners need a secure and orderly emotional environment, but also a physical environment that supports their learning. Teachers might be able to make large 100-squares, number squares for addition or eventually for multiplication, number lines, etc, for using in class. Those are flexible and can be used in lots of increasingly challenging ways as children come to understand number: it is better still if they can be painted onto classroom walls as a learning focus and reminder.

The numeracy-specific sections are based on the findings of the following reports:

Gifford, S. (2014) A good foundation for number learning for five-year-olds? An evaluation of the English Early Learning ‘Numbers’ Goal in the light of research, *Research in Mathematics Education*, 16:3, 219-233

Hodgen, J., Foster, C., Marks, R., & Brown, M. (2018). *Evidence for Review of Mathematics Teaching: Improving Mathematics in Key Stages Two and Three: Evidence Review*. London: Education Endowment Foundation. <https://educationendowmentfoundation.org.uk/evidence-summaries/evidence-reviews/improving-mathematics-in-key-stages-two-and-three/>

OECD (2018). *Lessons from Research about Quality in Early Childhood Education and Care* <http://www.oecd.org/education/engaging-young-children-9789264085145-en.htm>

NCETM (2008) *Mathematics matters* National Centre for Excellent in the Teaching of Mathematics. Available at <https://www.ncetm.org.uk/resources/12491>

Sim, M., Bélanger, J., Hocking, L., Dimova, S., Iakovidou, E., Janta, B. & Teager, W. (2018) *Teaching, pedagogy and practice in early years childcare: an evidence review* <https://www.eif.org.uk/files/pdf/teaching-pedagogy-and-practice-in-early-years-childcare.pdf>

Standards Unit (2002) *Improving Learning in Mathematics* London: Department for Education. Available at <https://www.stem.org.uk/elibrary/collection/2933> This is work which was originally developed for older secondary learners taking into account a range of international evidence, but has been successfully applied with much younger children.