



Developing mathematics-specific pedagogy in Initial Teacher Education

What are the key aspects of mathematics pedagogy for teaching that form the foundations for Initial Teacher Education (ITE)?

Beginning teachers need to know and understand the ways in which young people engage and learn mathematics and of different conceptions of the nature of mathematics and their impact on learning and teaching. This includes the contrasting and complementary roles of procedural/conceptual learning and relational/instrumental learning in developing learners' competence and understanding in mathematics. They also need to recognise the emotional and social aspects of learning of particular importance for learners of mathematics including: building confidence; developing resilience; creating a classroom environment in which learners conjecture and take risks; and an awareness of the impact of ability grouping on learners.

What mathematics-specific pedagogical approaches should ITE focus on?

For mathematics, ITE should focus on developing effective use of a variety of approaches to learning and the use of alternative methods and representations informed by a deep understanding of mathematics and an appreciation of how mathematics is understood by learners. In particular, knowledge of the 'big ideas' in mathematics, the connected nature of the discipline of mathematics (within itself and to other subjects/contexts), reasoning and proof, rigorous use of language and symbols. Investigative and problem solving approaches are essential pedagogical approaches for new teachers of mathematics to explore. Beginning teachers also need to learn the pedagogical skills of sequencing and choosing mathematical tasks and classroom activities, supporting and developing mathematical talk, planning lessons, recognising and working with errors and common misconceptions, understanding the role of manipulatives and diagrams in learning and doing mathematics, and assessing learning in the specific context of the mathematics classroom. In primary schools in particular, building a number-rich environment is an important aspect of supporting teaching that develops a coherent and rich approach to learning mathematics.

Are some mathematics-specific pedagogical approaches more important than others?

In teaching and learning mathematics, it is essential to take care and give time when generalising from physical experience to the symbolic and abstract. There is a need to recognise the value of both procedural and conceptual learning - and the relationships between them. Beginning teachers need to understand how fundamentally important it is that all learners should develop skills in mathematical reasoning through the use of high quality questions on the part of both teachers and learners. Recognising the importance of talk and language, and of models and images, in mathematics learning are essential to learning to be an effective teacher of mathematics. All learners need experiences that progress their learning and challenge their thinking, rather than experiences that are repetitive. Developing learners' positive attitudes to learning and their confidence to persevere and 'have a go' are essential attributes that beginning teachers need to develop in learners so that all have the opportunity to make progress and achieve success.

What activities and opportunities during ITE promote and develop learning mathematics-specific subject pedagogy?

It is essential that those on ITE programmes work collaboratively on mathematics tasks, both familiar and unfamiliar in a variety of contexts and have their personal experiences of learning

mathematics challenged. Beginning teachers need opportunities to reflect on their own learning and attitudes to mathematics and to draw out the pedagogical principles from those experiences. They need to reflect on the impact of their own learning experiences on the learning of those they work with, for example appreciating that alternative representations of a mathematical concept appeal to different learners and that others may learn mathematics differently to themselves. Beginning teacher of mathematics need opportunities to develop confidence and competence with a range of tools and resources (including digital resources) when solving mathematics problems for themselves as well as in supporting learners in choosing and using a range of tools in the classroom.

Those learning to teach mathematics also need structured activities and support that focuses on developing their understanding of mathematical progression - recognising and using prior learning, (within topics in mathematics as well as across topics) - so they can start to plan sequences of learning for mathematics classes. This is important both at the level of deconstructing and reconstructing mathematics at the micro level and more globally, in terms of planning for learners' future mathematical learning by building strong foundations. They need opportunities to work together with tutors and mentors to learn how to evaluate and adapt resources, design their own resources, and to identify tasks that engage and motivate learners from a range of prior attainment, backgrounds and cultures. Experiences in ITE need to cover a range of topics across mathematics and to explore the different models, representations and explanations that might be used to help learners develop their understanding, recognising their potential limitations through critical thinking and developing analytical skills.

Beginning teachers need opportunities to work with experienced specialist mathematics teachers through: observing and analysing good practice; shared planning, teaching and evaluation cycles (as in lesson study); and through supported analysis of and reflection on their own teaching. Such experiences need to challenge beginning teachers to develop their own teaching repertoire that allows learners the opportunity to work both collaboratively and individually, on short and extended problems, to tackle open and practical problems, to develop positive attitudes to mathematics, conceptual understanding and technical competence and, ultimately, to achieve as highly as possible. Learning to teach is a lifelong journey and those beginning that journey need an appreciation of the contributions that continuing professional development in a range of forms, including study at Masters level and becoming involved in a subject association can play in furthering that development.

Further reading

ACME, (2015), *Beginning teachers: Best in class?* [http://www.acme-uk.org/media/33228/acme%20initial%20teacher%20education%20\(ite\)%20report_web.pdf](http://www.acme-uk.org/media/33228/acme%20initial%20teacher%20education%20(ite)%20report_web.pdf) [accessed 22/9/16]

Association of Mathematics Teacher Educators, (2017), *Standards for Preparing Teachers of Mathematics*. Available online at www.amte.net/standards [accessed 6/3/17]

Ball, D., Thames, M. and Phelps, G. (2008) 'Content Knowledge for Teaching: What Makes It Special?', *Journal of Teacher Education*, 59(5), 389-407.

Black, P. & Wiliam, D., (1998), *Inside the Black Box: Raising standards through classroom assessment* Kings College, London

Boaler, J., Wiliam, D., & Brown, M. (2000), Students' experiences of ability grouping – disaffection, polarization and the construction of failure, *British Educational Research Journal*, 26 (5) 631-648. <https://bhi61nm2cr3mkdgtk1dtaov18-wpengine.netdna-ssl.com/wpcontent/uploads/BoalerWiliamBrownBERJ.pdf> [accessed 22/9/16]

Brown, L. (2003), 'Becoming a mathematician' *Mathematics Teaching* 182, 6-7

Burton, L. (2004), *Mathematicians as enquirers: Learning about learning mathematics*, Kluwer Academic: Norwell, Mass.

Education Endowment Fund, (n.d.), Teaching and Learning Toolkit, <https://educationendowmentfoundation.org.uk/evidence/teaching-learning-toolkit/> [accessed 22/9/16]

Ernest, P., (1989), 'The Impact of Beliefs on the Teaching of Mathematics', in P. Ernest, (Ed.) *Mathematics Teaching: The State of the Art*, Falmer Press: London, 249-254
<http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pmej/impact.htm> [accessed 22/9/16]

Lee, C. & Johnston-Wilder, S. (2010), Mathematical resilience, *Mathematics Teaching*, MT218, 38–41

Morgan, C. (2011), 'Communicating mathematically', Ch. 8 in Johnston-Wilder, S., Lee, C. & Pimm, D., (Eds) *Learning to teach mathematics in the secondary school: A Companion to school experience*, 3rd Edition, Routledge: Abingdon.

Ofsted, (2008), *Mathematics: Understanding the score*, Ofsted: London.
<http://dera.ioe.ac.uk/9250/3/index.html%3Ffile%3Ddocuments%252Fsurveys-and-good-practice%252Fm%252Fmathematics%20-%20understanding%20the%20score.pdf%26refer%3D0> [accessed 22/9/16]

Ofsted, (2011), *Mathematics: Made to measure*, Ofsted: Manchester
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/417446/Mathematics_made_to_measure.pdf [accessed 22/9/16]

Tall, D & Gray, E. (1994), Duality, Ambiguity and Flexibility: A Proceptual View of Simple Arithmetic, *The Journal for Research in Mathematics Education*, 26 (2), 115-141
<http://homepages.warwick.ac.uk/staff/David.Tall/pdfs/dot1994a-gray-irme.pdf> [accessed 22/9/16]

NCETM, (2011), *Initial Teacher education (ITE) Matters*,
<https://www.ncetm.org.uk/resources/33509> [accessed 22/9/16]

Rowlands, T. (2012), *The Knowledge Quartet* <http://www.knowledgequartet.org/> [accessed 22/9/16]

Shulman, L. (1987) 'Knowledge and teaching: Foundations of the new reform', *Harvard Educational Review*, 57(1), 1-21.

Skemp, R., (1976) Relational understanding and instrumental understanding, *Mathematics Teaching*, 77, 20–26. https://www.atm.org.uk/write/MediaUploads/Resources/Richard_Skemp.pdf [accessed 19/11/16]

17 March 2017

The Joint Mathematical Council of the United Kingdom is very grateful to Ros Hyde, Alison Clark-Wilson and others for their contributions to the preparation of this statement.