CAMBRIDGE Mathematics

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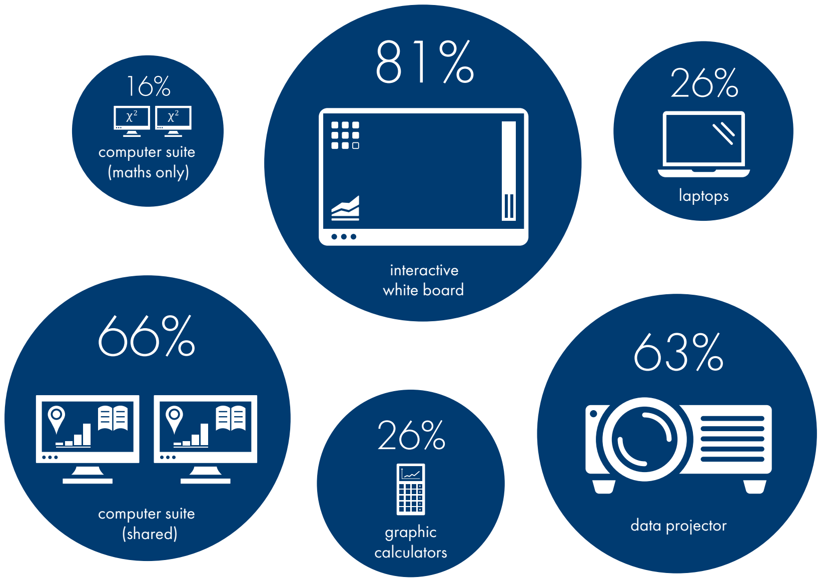
TALKING POINT:

WHAT ARE THE ISSUES AROUND USING DYNAMIC MATHEMATICAL TECHNOLOGY IN MATHEMATICS LEARNING?

IN SUMMARY

- Dynamic mathematical software consists of tools and environments to support mathematical thinking
- These offer opportunities to reconceptualise the underlying mathematics through different and linked mathematical representations, accessible to students at different levels
- Use of graphing software or dynamic work on mathematical objects can help shift focus to underlying concepts
- Use of dynamic mathematical software can promote collaboration and shift the centre of expertise away from the teacher; teachers should plan for this shift
- There is a clear need for more good-quality sustained CPD for teachers on the use of dynamic mathematical software, through the use of MOOCs and online toolkits
- Technology use in assessment and curriculum should be carefully planned for coherence and with teacher support in mind

Percentage of secondary mathematics teachers surveyed with access to technological hardware (n = 89)



(Adapted from Bretscher, 2011)

1 Dynamic mathematical technology for mathematics learning, also called dynamic mathematics software[1], refers explicitly to mathematical software designed to help students learn about mathematics in a way that is interactive or movable, as opposed to a merely static presentation of information using technology. This technology can be a mathematical 'tool' that 'offers a mathematical environment within which to explore, express and communicate mathematical ideas'[2]. Interacting with technology not only superficially adjusts, but actually reorganises student thinking about mathematics[3].

IMPLICATIONS: Exploration and communication of mathematical ideas may be enhanced by use of dynamic mathematical technology

The dynamic nature of experiences using dynamic mathematical technology enables students to reorganize their thinking

'When teachers use technology strategically, they can provide greater access to mathematics for all students'

NCTM (US)

'Mathematical experiences emerge from the distributed interactions enabled by the mobility and shareability of representations'

Moreno-Armella et al

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Dynamic mathematical technology offers a substantial benefit: multiple representations, which refers to different representations which are often linked and can offer different entry points to the mathematical idea or concept[3]. For example, the use of graphing software has enabled graph plotting to be done quickly and accurately and provides the opportunity for the focus to shift to the underlying conceptual links or key statistical concepts, enabling graphs and functions to be considered within 'real-life' contexts, where appropriate. It may also make it possible to use 'messy' real-life datasets[4]. Dynamic mathematical technology also allows co-action between student and software (the idea that a user can guide and/or simultaneously be guided by a dynamic software environment) and gives instant feedback to the user, enabling students' conjectures to be confirmed or refuted[2]. Students can learn about geometric properties through tangible actions on dynamic shapes rather than merely 'naming of parts', leading to higher levels of engagement with the mathematical ideas.

IMPLICATIONS: Different and linked representations of maths offered through technology can support students with accessing mathematical ideas at different levels

Graphing software can help shift focus to underlying concepts and allow for easier use of real-life data

Instant feedback and dynamic action on mathematical objects like shapes can allow students to engage with ideas at a higher level

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A significant barrier to teacher use is the lack of sufficient and appropriate professional development. There is a clear need for sustained and substantive professional development opportunities on the use of dynamic mathematical software[5,6,7]. New professional development models are needed such as Massive Open Online Courses (MOOCs)[8], online toolkits[9] and school-based applications of these[10]. Many teachers are unaware of the range of mathematical digital resources available[11] and would benefit from support which enables them to experience tasks in the digital environment, to see how the mathematical progression might change and to appreciate the new forms of knowledge that might be possible[12]; however these opportunities currently vary greatly within and across different countries[2]. Use of dynamic mathematical technology can also prompt new ways of thinking about maths which are more collaborative and distributed and less centred around the teacher as the (only) source of expertise[13]. Increasing students' autonomy and agency through the use of dynamic representations prompts the teacher's role to shift to focus on sharing and brokering the mathematical ideas through new approaches to formative assessment[14].

IMPLICATIONS: Teachers benefit from sustained and supportive professional development such as MOOCs and online toolkits to help them teach using dynamic mathematical software

Use of dynamic mathematical software can promote collaboration and teamwork and shift the centre of expertise away from the teacher; the teacher's role may need to shift towards brokering ideas

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A country's (or region's) policy for technology use in its mathematics curriculum (and the associated assessment regime) has long been cited as a potential catalyst or barrier to technology use[15]. For example, mandating technology use in examinations is a known factor that increases classroom usage by teachers and students[16]. However, mandating technology use alone, without also considering the impact on the nature of the curriculum and its assessment, has limited effect[16]. The diversity of mathematical technological tools, with very different appearances, functionalities and syntaxes, are making the challenge of coherence across curriculum, assessment and professional development increasingly complex. Emerging technologies such as handwriting recognition, natural language processing and graphical interfaces may offer some solutions[17].

IMPLICATIONS: The way that technology use is referred to in curriculum and assessment has potent effects and should be considered as a coherent whole by policymakers and curriculum developers

More consistency of interfaces across dynamic mathematical software options, such as handwriting recognition or natural language processing, would enable greater access to mathematics

Lucy Rycroft-Smith & Alison Clark-Wilson (UCL Institute of Education), 2019

REFERENCES

1. Moreno-Armella, L., Hegedus, S. J., & Kaput, J. J. (2008). From static to dynamic mathematics: historical and representational perspectives. *Educational Studies in Mathematics, 68*(2), p. 99-111.
2. Clark-Wilson, A. (2019). Mathematics Education and Technology. In A. Tatnell (Ed.), *Encyclopedia of Education and Information Technologies*. Dordrecht: Springer.
3. Borba, M. C., & Villareal, M. E. (2005). *Humans-with-Media and the Reorganization of Mathematical Thinking*. US: Springer.
4. Confrey J., & Maloney A. (2007). A Theory of Mathematical Modelling in Technological Settings. In W. Blum, P. L. Galbraith, H. W. Henn, & M. Niss (Eds.), *Modelling and Applications in Mathematics Education* (pp. 57-68).
5. Thomas, M. O. J., & Hong, Y. Y. (2013). Teacher integration of technology into mathematics learning. *International Journal for Technology in Mathematics Education, 20*, 69-84.
6. Clark-Wilson, A., & Hoyles, C. (2018). A research-informed web-based professional development toolkit to support technology-enhanced mathematics teaching at scale. *Educational Studies in Mathematics.*
7. Drijvers, P., Tacoma, S., Besamusca, A., Doorman, M., & Boon, P. (2013). Digital resources inviting changes in mid-adopting teachers' practices and orchestrations. *ZDM, 45*(7), 987-1001.
8. Taranto, E., Ferdinando, A., & Robutti O. (2017). Analysing MOOCs in terms of their potential for teacher collaboration: The Italian experience. In T. Dooley & G. Gueudet (Eds.), *Proceedings of the Tenth Conference of the European Society for Research in Mathematics Education (CERME 10)*(pp. 2478-2485), Dublin: Ireland: DCU Institute of Education and ERME.
9. Clark-Wilson, A., & Hoyles, C. (2015). Blended learning and e-learning support within the Cornerstone Maths Project. In K. Maaß, B. Barzel, G. Törner, D. Wernisch, E. Schäfer, & K. Reitz-Koncebovski (Eds.), *Educating the Educators: International approaches to scaling-up professional development in maths and science education* (pp. 158-166).
10. Clark-Wilson, A. (2017). Transforming mathematics teaching with digital technologies: a community of practice perspective. In A. Marcus-Quinn & T. Hourigan (Eds.), Handbook on *Digital Learning for K-12* (pp. 45-57).
11. Umameh, M., & Monaghan, J. (2017). A Classification of resources used by mathematics teachers in an English high school. In G. Aldon & J. Trgalova (Eds.), 1*3th International Conference on Technology in Mathematics Teaching* (pp. 278-283).
12. Clark-Wilson, A., & Hoyles, C. (2017). *Dynamic technology for dynamic maths [Executive Summary]*. London: UCL IOE Press.
13. Gadanidis, G., & Geiger, V. (2010). A social perspective on technology-enhanced mathematical learning: from collaboration to performance. *ZDM, 42*(1), 91-104
14. Clark-Wilson, A., Robutti, O., & Sinclair, N. (2014). *The Mathematics Teacher in the Digital Era*, Dordrecht: Springer.
15. Hoyles, C., & Lagrange, J. B. (2009). *Digital technologies and mathematics teaching and learning: Rethinking the terrain*. Berlin: Springer.
16. Sinclair, N., Arzarello, F., Trigueros Gaisman, M., & Lozano, D., (2009). Implementing Digital Technologies at a National Scale. In C. Hoyles & J. B. Lagrange (Eds.), *Mathematics Education and Technology - Rethinking the Terrain: The 17th ICMI Study* (pp. 61-80).
17. Anthony, L., Yang, J., & Koedinger, K. R. (2007). Benefits of Handwritten Input for Students Learning Algebra Equation Solving. In R. Luckin, K. R. Koedinger, & J. Greer (Eds.), *Proceedings of the 2007 Conference on Artificial Intelligence in Education: building technology rich learning contexts that work* (pp. 521-523), Amsterdam: IOS Press.