Evidence Summary—Technical Annex:

Overall, there is strong evidence that early maths approaches can be effective. The Early Years Toolkit (EEF, 2023) estimates that children who take part in an early numeracy intervention make, on average, seven months' additional progress compared with peers who do not take part. Multiple systematic reviews found similarly positive effects for early maths interventions (Malofeeva, 2005; Nelson and McMaster, 2019a; Wang et al., 2016) including for pupils at risk of maths difficulties (Mononen et al., 2014). Nelson and McMaster (2019a) found that interventions targeting younger children (aged four to six) are more effective than those targeting first graders (aged six to seven) while Wang et al. (2016) found some provisional evidence that interventions are equally effective for younger children (aged three to five) and kindergartners (aged five to six). This suggests that early years settings have an opportunity to have a significant impact on even young children's maths ability before they start school.

The evidence suggests that early maths teaching can be successfully implemented in different ways. A systematic review (Hodgen et al., 2020) found that whole curriculum interventions can have a positive effect on maths outcomes, aligning with the positive results from an additional set of primary studies evaluating whole curriculum programmes (for example, Doabler et al., 2016; Starkey et al., 2004). It should be noted that there is large variation in the effectiveness of programmes and between different evaluations of the same programme (Hodgen et al., 2020; Nelson and McMaster, 2019b). This may be due to characteristics of the samples included in the studies or differences in implementation. A systematic review (Wang et al., 2016) found that supplemental interventions can be as effective as whole-curriculum interventions, and there is some evidence that integrating maths activities into daily routines at points throughout the day can be an effective approach (Arnold et al., 2002; Chard et al., 2008; Institute of Education Sciences, 2007). The findings from systematic reviews suggest that interventions can be delivered effectively in different group sizes, including whole-class and flexible grouping arrangements (Mononen et al., 2014; Nelson and McMaster, 2019a; Wang et al., 2016). Mononen et al. (2014) emphasised the staffing and resource costs in delivering small group and one to one interventions. It may be worthwhile, therefore, for educators to consider how to target this more intensive support to those who are falling behind.

Children, it seems, can learn maths through play, through explicit teaching, or a combination of both. Hodgen et al. (2020), however, found minimal experimental research testing the effectiveness of play but the evidence that does exist seems positive (ibid.; Skene et al., 2022). Other systematic reviews found that interventions that include games can be effective for kindergartners (Malofeeva, 2005; Mononen et al., 2014; Turgut and Temur, 2017). Hodgen et al. (2020) noted that some successful programmes include elements of both play and explicit teaching (for example, Institute of Education Sciences, 2007) and that the evidence around explicit teaching itself is strong and positive. Mononen et al. (2014) found that explicit teaching can be an aspect of successful interventions for pupils at risk of maths difficulties too.

The evidence around educational technology (EdTech) is generally positive but not consistently so, perhaps because it is not a unified approach in itself but an umbrella term including a range of tools and devices that facilitate other approaches. Systematic reviews have found that interventions that include EdTech can have a positive impact on maths outcomes (Ran et al., 2021; Verbruggen et al., 2021), including for children at risk of learning difficulties in maths (Benavides-Varela et al., 2021; Ran et al., 2021). Malofeeva (2005) found that interventions that include EdTech are less effective than other approaches, albeit still effective. With regard to specific approaches and devices, there is evidence that EdTech that teaches or provides practice for aspects of maths—for example, through games—can support young children's maths learning (Hodgen et al., 2020). Less is known about the effect of technological tools like calculators and robots for young children because less research has been conducted on these (ibid.). Griffith et al. (2020) found that apps with interactive elements only sometimes improve children's maths outcomes. There is also some evidence that EdTech programmes that focus on metacognition can support even young children's maths learning (Verschaffel et al., 2019).

Regarding how EdTech should be used in the classroom, one systematic review (Verbruggen et al., 2021) found that it was more effective for maths learning when children were provided with support by the educator and when it was used individually rather than cooperatively, perhaps because cooperative learning requires additional skills. Additionally, the authors found no evidence that socioeconomic status was associated with EdTech effectiveness (ibid.). However, other reviews have noted that in older age groups there is the risk of a digital divide widening the attainment gap between disadvantaged pupils and their peers (Vicentini et al., 2022; Walker et al., 2022). It seems that EdTech has the potential to facilitate learning in maths, however, it seems particularly important that educators monitor the effect of interventions involving EdTech, especially for disadvantaged pupils.

1. Explicit teaching refers to formal, educator-directed approaches in which educators explicitly support children to develop specific ideas and skills.
'Metacognition can be seen as the instructions we give ourselves on how to do a particular learning activity or task' (Muijs and Bokhove, 2020, p.7).

Evidence Summary—Technical Annex:

Some research has explored the effectiveness of additional targeted teaching, that is, one to one or small group support that is delivered by an adult in addition to usual instruction. In some research, this is called 'tutoring'. The effect of this kind of targeted additional support on maths outcomes for children in the early years is unclear and more research is needed. Systematic reviews have concluded that it can improve children's outcomes (Pellegrini et al., 2021), including when it is targeted at low-attaining pupils (Hodgen et al., 2020), however, both these reviews combined evidence from the early years and later stages of schooling. Elsewhere, a systematic review found insufficient evidence for preschoolers on this topic to conclude that additional targeted teaching significantly improves maths achievement for this age group (Nickow et al., 2020).

Other research has explored the effect of peer-assisted learning (sometimes called 'peer tutoring') in which children support each other to learn. Systematic reviews have concluded that interventions incorporating peer-assisted learning as one component of a wider intervention impact maths outcomes positively (Hodgen et al., 2020; Malofeeva, 2005; Nelson and McMaster, 2019a). However, Nelson and McMaster (2019a) concluded that interventions that incorporate peer-assisted instruction had a comparatively smaller impact than many other mathematics interventions.

There is widespread consensus that educators' knowledge of maths and of young children's development in maths supports early mathematical learning. Yet, systematic reviews have identified relatively little impact research on professional development (PD) in early years maths (Brunsek et al., 2020; Hodgen et al., 2020). However, one recent example of a successful programme is Maths Champions: this is a PD programme that builds the knowledge of early years practitioners to improve maths practice in their setting. A recent evaluation indicated that children made an additional three months' progress in both maths and language attainment in settings implementing Maths Champions (Robinson-Smith et al., 2023). Given the success of this programme, maths PD may be a promising area for further research.

References

Systematic reviews and meta-analyses:

1. Benavides-Varela, S., Zandonella Callegher, C., Fagiolini, B., Leo, I., Altoè, G. and Lucangeli, D. (2020) 'Effectiveness of Digital-Based Interventions for Children with Mathematical Learning Difficulties: A Meta-Analysis', *Computers and Education*, 157 (Nov 2020, 103953). https://doi.org/10.1016/j.compedu.2020.103953

2. Brunsek, A., Perlman, M., McMullen, E., Falenchuk, O., Fletcher, B., Nocita, G., Kamkar, N. and Shah, P. S. (2020) 'A Meta-Analysis and Systematic Review of the Associations Between Professional Development of Early Childhood Educators and Children's Outcomes', *Early Childhood Research Quarterly*, 53, pp. 217–248. https://doi.org/10.1016/j.ecresq.2020.03.003

3. Griffith, S. F., Hagan, M. B., Heymann, P., Heflin, B. H. and Bagner, D. M. (2020) 'Apps as Learning Tools: A Systematic Review', *Pediatrics*, 145 (1), 1–14. https://doi.org/10.1542/peds.2019-1579

4. Hodgen, J., Barclay, N., Foster, C., Gilmore, C., Marks, R. and Simms, V. (2020) 'Early Years and Key Stage 1 Mathematics Teaching: Evidence Review', London: Education Endowment Foundation.

5. Institute of Education Sciences (2007) 'SRA Real Math Building Blocks PreK: WWC intervention report', U.S. Department of Education.

6. Malofeeva, E. V. (2005) 'Meta-Analysis of Mathematics Instruction with Young Children' (unpublished doctoral dissertation), University of Notre Dame, IN.

7. Mononen, R., Aunio, P., Koponen, T. and Aro, M. (2014) 'A Review of Early Numeracy Interventions for Children at Risk incMathematics', *Early Childhood Special Education*, 6 (1), 25–54. https://doi.org/10.20489/intjecse.14355

8. Nelson, G. and McMaster, K. L. (2019a) 'The Effects of Early Numeracy Interventions for Students in Preschool and Early Elementary: A Meta-Analysis', *Educational Psychology*, 111 (6), pp. 1001–022. https://doi.org/10.1037/edu0000334

9. Nelson, G. and McMaster, K. L. (2019b). 'Factors that May Influence Treatment Effects: Helping Practitioners Select Early Numeracy Interventions', *Learning disabilities research and practice*, 34(4), pp. 194-206. https://doi.org/10.1111/ldrp.12208

References

10. Nickow, A., Oreopoulos, P. and Quan, V. (2020) 'The Impressive Effects of Tutoring on Prek-12 Learning: A Systematic Review and Meta-Analysis of the Experimental Evidence, Working Paper 27476', Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w27476

11. Pellegrini, M., Lake, C., Neitzel, A. and Slavin, R. E. (2021) 'Effective Programs in Elementary Mathematics: A Meta-Analysis', *AERA Open*, 7, pp. 1–29. https://doi.org/10.1177/2332858420986211

12. Ran, H., Kasli, M. and Secada, W. G. (2021) 'A Meta-Analysis on Computer Technology Intervention Effects on Mathematics Achievement for Low-Performing Students in K-12 Classrooms', *Educational Computing Research*, 59 (1), pp. 119–153. https://doi.org/10.1177/0735633120952063

13. Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C. and Ramchandani, P. G. (2022) 'Can Guidance During Play Enhance Children's Learning and Development in Educational Contexts? A Systematic Review and Meta-Analysis', *Child Development*, 93 (4), pp. 1162–180. https://doi.org/10.1111/cdev.13730

14. Turgut, S. and Temur, Ö. D. (2017) 'The Effect of Game-Assisted Mathematics Education on Academic Achievement in Turkey: A Meta-Analysis Study', *Elementary Education*, 10 (2), pp. 195–206. https://doi.org/10.26822/iejee.2017236115

15. Verbruggen, S., Depaepe, F. and Torbeyns, J. (2021) 'Effectiveness of Educational Technology in Early Mathematics Education: A Systematic Literature Review', *Child-Computer Interaction*, 27 (March 2021, 100220). https://doi.org/10.1016/j.ijcci.2020.100220

16. Verschaffel, L., Depaepe, F. and Mevarech, Z. (2019) 'Learning Mathematics in Metacognitively Oriented ICT-Based Learning Environments: A Systematic Review of the Literature', *Education Research International*, 2019, pp. 1–19. https://doi.org/10.1155/2019/3402035

17. Walker, M., Bradley, E., Sharp, C., Grayson, H., Lopes, G. and Chu, J. (2022) 'Education Technology for Remote Teaching', London: Department for Education.

18. Wang, A. H., Firmender, J. M., Power, J. R. and Byrnes, J.P. (2016) 'Understanding the Program Effectiveness of Early Mathematics Interventions for Prekindergarten and Kindergarten Environments: A Meta-Analytic Review', *Early Education and Development*, 27 (5), pp. 692–713. https://doi.org/10.1080/10409289.2016.1116343

Primary Studies

19. Arnold, D. H., Fisher, P. H., Doctoroff, G. L., & Dobbs, J. (2002). 'Accelerating math development in Head Start classrooms', *Journal of Educational Psychology*, 94(4), pp. 762–770. https://doi.org/10.1037/0022-0663.94.4.762

20. Chard, D. J., Baker, S. K., Clarke, B., Jungjohann, K., Davis, K. and Smolkowski, K. (2008) 'Preventing Early Mathematics Difficulties: The Feasibility of a Rigorous Kindergarten Mathematics Curriculum', *Learning Disability Quarterly*, 31 (1), pp. 11–20. https://doi.org/10.2307/30035522

21. Doabler, C. T., Clarke, B., Kosty, D. B., Kurtz-Nelson, E., Fien, H., Smolkowski, K. and Baker, S. K. (2016) 'Testing the Efficacy of a Tier 2 Mathematics Intervention: A Conceptual Replication Study', *Exceptional Children*, 83 (1), pp. 92–110. https://doi.org/10.1177/0014402916660084

22. Robinson-Smith, L., Whiteside, K., Torgerson, C., Fairhurst, C., Podmore, D., Davill, T., Bell, K., Qi, X., Leggett, H., Elliott, L., Hewitt, C., Baird, K., Menzies, V., Torgerson, D. and Ainsworth, H. (2023) 'Independent Evaluation of Maths Champions in Nursery to Develop Children's Early Numeracy: A Two-Armed Cluster Randomised Controlled Trial. Evaluation Report', London: Education Endowment Foundation.

23. Starkey, P., Klein, A. and Wakeley, A. (2004) 'Enhancing Young Children's Mathematical Knowledge Through a Pre-Kindergarten Mathematics Intervention', *Early Childhood Research Quarterly*, 19 (1), pp. 99–120. https://doi.org/10.1016/j.ecresq.2004.01.002