# USING DIGITAL TECHNOLOGY TO IMPROVE LEARNING

Guidance Report

Education Endowment Foundation

The authors would like to thank the many researchers and practitioners who provided support and feedback on drafts of this guidance. In particular, we would like to thank the Advisory Panel and Review Team:

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# FOREWORD

We live in a digital age. Technology has transformed how we do things, from communication with friends and family to learning about the world around us. The pupils we teach do not know a life without it. The opportunities it offers us to improve education are truly exciting. The question is no longer *whether* technology should have a place in the classroom, but *how* technology can most effectively be integrated in ways which achieve improved outcomes for young people.

This EEF guidance report is designed to support senior leaders and teachers to make better informed decisions based on the best available evidence we currently have. It includes a number of practical examples of technology being used in ways which support improved teaching and learning.

*"The question is no longer **whether** technology should have a place in the classroom, but **how** technology can most effectively be integrated"*

We have developed it for three key reasons. First, because as technology advances at lightning pace, it can be difficult for schools to decide which innovations to commit their scarce time and resources to.

Secondly, because an overarching recommendation in this report is that technology itself is unlikely to improve young people's learning, but the pedagogy behind it can. Put simply, this means buying a tablet for every pupil is unlikely to boost pupil attainment. However, if those tablets are used purposefully – for example, increasing the quality or quantity of practice pupils undertake through a quiz app, or the precision with which feedback on misunderstandings is provided – they stand a much better chance of doing so.

Thirdly, and this is a consistent theme in our guidance reports, good implementation is crucial to success. This means that once you have considered the pedagogical rationale for putting a new technology to work, you have to ensure your school has the capacity to implement it effectively. This is likely to require both upfront training and follow-on supporting activities back in the school to ensure teachers are able to apply it effectively within the busy reality of their classroom.

To develop this report's four recommendations for using digital technology to improve pupils' learning we not only reviewed the best available international research, but also consulted with teachers and other experts.

As with all EEF guidance reports, its publication is just the start of how we aim to support schools in implementing these recommendations. We will now be working with the sector, including through our colleagues in the Research Schools Network, to build on them with further training, resources and tools.

And, as ever, we will be looking to support and test the most promising programmes that put the lessons from the research into practice. Our hope is that this guidance will help to support a consistently excellent, evidence-informed education system in England that creates great opportunities for all children and young people, regardless of their family background.

**Sir Kevan Collins**

Chief Executive
Education Endowment Foundation

# INTRODUCTION

## What does this guidance cover?

This guidance report aims to help schools consider how they can use digital technology to improve pupils' learning. Schools use technology in many ways and with a wide range of aims, from those that seek to change classroom practice directly to others that support schools more broadly, for example by tracking pupil data or to facilitate a whole-school behaviour management policy. Though some wider uses are mentioned, the main focus of this report is on applications of technology that aim to improve learning directly. The report does not focus on teaching computing or coding, or on questions related to screen time or the use of mobile devices.

This report provides guidance for schools based on the best available evidence. Summarising evidence on technology is challenging due to the speed of development within the field, the variety of ways in which technology has been applied in the classroom, and the diversity of contexts in which technology has been studied. Nonetheless, it is striking that, across an evidence base that has been built over 40 years, some common messages clearly emerge.

The most enduring of these messages is that **to improve learning, technology must be used in a way that is informed by effective pedagogy**. The question of how to use technology to improve learning is not distinct from the question of how to teach effectively, or of how children learn. That is why, in addition to providing an overarching framework for considering how technology is best used in the classroom (Recommendation 1), this report has been structured around some of the key elements of effective teaching: explanations and modelling (Recommendation 2); pupil practice (Recommendation 3); assessment and feedback (Recommendation 4).

Alongside the importance of pedagogy, this report's second overarching message is about **the importance of implementation**. Poor implementation is a key reason that digital technology fails to meet its potential to improve learning. As a consequence, this guidance draws not just on the academic literature exploring the impact of technology, but also on the wider evidence about implementation and effective teaching practices more broadly.

Technology has the potential to improve teaching and learning in a wide variety of ways. But 'potential' is the pivotal word. Alongside examples where technology has enhanced learning are many others where technology has fallen short. Understanding how technology's potential can be realised is a key question for teachers and school leaders today.

## Acting on the guidance

To maximise its impact, this report should be read in conjunction with other EEF guidance including *Putting Evidence to Work: A School's Guide to Implementation* and subject-specific reports on literacy, mathematics, and science (all available at: https://educationendowmentfoundation.org.uk/tools/guidance-reports).

> *"To improve learning, technology must be used in a way that is informed by effective pedagogy"*

Schools may also want to seek support from our national network of Research Schools, a collaboration between the EEF, the Institute for Effective Education, and the Department for Education. Research Schools aim to lead the way in the use of evidence-based teaching, building affiliations with large numbers of schools in their region, and supporting the use of evidence at scale.

## Who is this guidance for?

This guidance is applicable to all schools, colleges, and early years settings, but most research is on school age (and older) learners. It is aimed primarily at senior leaders who are thinking about their school's approach to using digital technology, and those with responsibility for technology across a number of schools. However, it is also hoped that many of the lessons will be useful for class teachers. Further audiences who may find the guidance relevant include governors, parents, programme developers, policy makers, and educational researchers.

# SUMMARY OF RECOMMENDATIONS

## 1

### Consider how technology will improve teaching and learning before introducing it

- New technology can often appear exciting. However, it can become a solution in search of a problem unless it is introduced in response to an identified need. It is often useful to link the introduction of new technology to wider planning, for example, a review of assessment policy.
- Schools should consider the pedagogical rationale for how technology will improve learning. The principles of how to use technology successfully are not distinct from questions of how to teach effectively or how children learn.
- Without a clear plan for support and implementation, technology is much less likely to have an impact. This includes considering what initial training will be needed, what time and resources are required, and what ongoing support should be available.
- Decisions about whether to introduce technology should also include an analysis of the costs of implementing the technology, alongside the expected benefits. This should include both the upfront costs and any ongoing requirements.

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## 2

### Technology can be used to improve the quality of explanations and modelling

- Technology has the potential to help teachers explain and model new concepts and ideas. However, how explanations and models are conveyed is less important than their clarity, relevance and accessibility to pupils.
- Introducing a new form of technology will not automatically change the way teachers teach. The introduction of interactive whiteboards provides an example that highlights the need to consider the pedagogical rationale for adopting a form of technology, and for carefully planning the training required to enable teachers to use it effectively.
- Technology can help teachers model in new ways and provide opportunities to highlight how experts think as well as what they do, but may be most effective when used as a supplement rather than a substitute for other forms of modelling.

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# 3

## Technology offers ways to improve the impact of pupil practice

- Technology has the potential to increase the quality and quantity of practice that pupils undertake, both inside and outside of the classroom.
- Technology can be engaging and motivating for pupils. However, the relationship between technology, motivation and achievement is complex. Monitoring how technology is being used, including by checking that all learners have the skills they need to use it effectively, is likely to reduce the risk that technology becomes a tool that widens the gap between successful learners and their peers.
- Some forms of technology can also enable teachers to adapt practice effectively, for example by increasing the challenge of questions as pupils succeed or by providing new contexts in which students are required to apply new skills.
- Using technology to support retrieval practice and self-quizzing can increase retention of key ideas and knowledge.

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# 4

## Technology can play a role in improving assessment and feedback

- Technology has the potential to improve assessment and feedback, which are crucial elements of effective teaching. However, how teachers use information from assessments, and how pupils act on feedback, matter more than the way in which it is collected and delivered.
- Using technology can increase the accuracy of assessment, and the speed with which assessment information is collected, with the potential to inform teachers' decision-making and reduce workload.
- Technology can be used to provide feedback directly to pupils via programmes or interventions, but in all cases careful implementation and monitoring are necessary. Feedback via technology is likely to be most beneficial if it supplements, but is aligned to, other forms of feedback.

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# 1 Carefully consider how technology is going to improve teaching and learning before introducing it

It is impossible to talk about the impact of technology on pupil outcomes as if technology were a single approach. Technology can be used in schools in many different ways, for a variety of purposes, and undoubtedly has the potential to improve learning. But the range in the size of the impacts seen in evaluations of educational technology is very wide. This variation is shown in Table 1, which summarises a range of results from evaluations of educational technology funded by the Education Endowment Foundation.

Importantly, the variability in the impact of digital technologies can be seen both *between approaches and within evaluations of the same approach*. This suggests that the degree to which technology improves learning is likely to depend on both **pedagogical factors**, related to the underlying design of the approach, and **school-specific factors**, related to the degree to which the approach solves a particular school's needs and how effectively the approach is implemented.

This section provides a framework for considering how and whether to use new forms of technology in the classroom.

## Define a learning need first

Technology is much more likely to improve learning if it is introduced in response to an identified need. Particularly when schools are under pressure to improve outcomes, it can be tempting to introduce new programmes or products before thoroughly considering whether they are likely to provide solutions to existing priorities for improving teaching and learning.

This is a particular risk with technology, where novel products or apps can often appear exciting and impressive, and can be heavily marketed by developers, regardless of whether they are right for the school. All teachers will have examples of technology proving to be less reliable and easy-to-use than they were promised it would be. Many schools will have stories of licences for software that have been bought only to be used for a few weeks, or of hardware languishing in cupboards once the teacher who had advocated for their use has left the school. Such episodes can be understood by drawing a distinction between 'early users' and 'late adopters'. Whereas early users might typically introduce an innovation with enthusiasm and a clear rationale in mind, there is a risk that those who get involved later miss this reasoning, and either use the innovation ineffectively or reject it altogether.[1]

One way of reducing the risk of technology being 'a solution in search of a problem' is to ensure that school leaders focus first on defining the problem to be solved before identifying programmes or practices to implement as the solution.[2] This process can also be linked to wider planning, for example as part of departmental development plans, or the development of a school's pupil premium strategy.

**Table 1: Examples of EEF funded findings of projects with technology inputs***

| Name | What is it? | Summary of findings | *Evidence Rating* | *Months Progress* |
|---|---|---|---|---|
| ABRA | A 20-week online literacy programme focusing on phonic fluency and comprehension activities. The study also evaluated the effect of a paper-based version of the ABRA tool. | Positive effects were found for online and paper versions of ABRA (between 2 and 5 additional months progress for pupils in Key Stage 1). | (Online) | +2 |
| Accelerated Reader | Internet-based software that assesses reading age, and suggests books that match pupils' needs and interests. | Trial found Key Stage 3 pupils using accelerated reader made 3 months' additional progress in reading compared to other similar pupils. | | +3 |
| Affordable Maths Tuition | One-to-one tutoring programme where pupils receive mathematics tuition over the internet from trained maths graduates in India and Sri Lanka. | The evaluation found no evidence that the intervention had an impact on Key Stage 2 mathematics, compared with 'business as usual' teaching and support in Year 6. | | +0 |
| GraphoGame Rime | Computer game designed to teach pupils to read by developing their phonological awareness and phonic skills. | No evidence that GraphoGame Rime improves Key Stage 1 pupils' reading or spelling test scores when compared to business-as-usual. | | -1 |
| Learner Response System | A set of electronic hand-held devices which allow pupils to respond to questions during lessons. Teachers are able to see an instant summary of responses and can provide real-time feedback. | The evaluation found no evidence that Key Stage 2 results in maths and reading were improved for pupils using the system for 2 years. | | +0 |
| Mathematical Reasoning | 10 hour-long units delivered by teachers as part of their usual mathematics lessons, with learning supported by online games. | Effectiveness Trial: Small positive effects on maths attainment<br>Efficacy Trial: Large positive effects on maths attainment | | +1<br>+3 |
| Maths Flip | An online 'flipped learning' programme in which pupils learn core content online, outside of class time and then participate in activities in class to reinforce their learning. | Pupils who were taught new mathematics topics using MathsFlip for one year made a small amount of additional progress in Key Stage 2 mathematics, equivalent to about 1 month. | | +1 |
| Texting Parents | Texts informed parents about dates of upcoming tests, whether homework was submitted on time, and what their children were learning at school | This evaluation found a small positive impact on mathematics attainment and on decreasing absenteeism. | | +1 |

* ***We have included the most relevant results published by December 2018 that had an EEF security rating of at least 3 padlocks out of a maximum of 5, meaning they are of moderate to very high security.***

## Be clear on the rationale for how technology will improve learning

Once a problem has been identified and well defined, it is time to consider why technology might provide an effective solution. Three questions to consider at this stage include:

1. How tightly does it link to the problem that you have identified? For example, does the reading programme you are considering focus on the aspect of reading (decoding, fluency, comprehension) that your pupils are struggling with most?

2. How will it change teaching? For example, will teachers find it easier to explain, model, assess progress or provide feedback?

3. How will it improve learning? For example, will pupils work more efficiently, more effectively, with more time on task? Will the technology help them to learn for longer in more depth, more productively?

By asking these questions, it will be easier to assess the pedagogical rationale for introducing new technology, and to understand the key active ingredients that influence how technology can be integrated into existing classroom practice (see Box 1).[3] The key message is that to improve learning, technology must be introduced in a way that is informed by effective pedagogy. The question of how to use technology to improve learning is not distinct from the questions of how to teach effectively, or of how children learn.[1]

Wider benefits, for example related to workload or parental engagement, could also be identified as part of the same process. For example, an EEF trial of using text messages to keep parents informed and engaged in secondary pupils' learning found that it led to small improvements in attainment in mathematics, as well as reducing absenteeism and improving parental involvement.[4]

### Box 1: Is technology the active ingredient?

Often, evaluations of digital interventions compare whether pupils who receive support through technology make more progress than others who continue with normal classroom practice. However, in some studies, delivering support digitally is compared to delivering the same type of support in another way.

A 2016 EEF study did just this, focusing on a well-researched literacy programme, ABRA.[15] Developed by Concordia University, ABRA is a game-based balanced literacy intervention that aims to support beginner readers.

The study compared the progress of Year 1 pupils using the online ABRA programme with a second group of pupils who worked through similar content delivered using pencil and paper, and additional resources such as magnetic letters and cards. Each of activities in the online programme was matched by a non-digital version, and using the same stories, vocabulary items, questions, words, and letter sounds in the activities. It was therefore almost identical in content to the online version and only differed in terms of delivery medium. A further group of pupils were randomised to continue their usual lessons.

Pupils in the digital ABRA group and the non-digital group made similar amounts of progress, and both groups made greater progress than pupils in the control group. There may be advantages to the online version, such as efficiency or cost, but this example is consistent with the idea that the content of the intervention, which was carefully designed by experts in literacy development, is likely to be more important than the delivery method. Arguably, the content and pedagogy underpinning ABRA was the 'active ingredient' in the project.[16]

## Consider whether technology will supplement, enhance or replace existing teaching

To date, technology has been most effective when it is used to supplement or enhance teaching, rather than to replace it. In studies with the largest recorded impacts, technology typically provides access to additional resources and opportunities for additional learning time.[1,5,6,7,8]

Where technology is effectively used to improve teaching and learning activities, it is carefully integrated into lessons by teachers and teaching assistants trained in its use, and trained to support pupils to use it effectively.[9,10] For example, Mathematical Reasoning is a programme developed by academics for Year 2 pupils, which integrates lesson content for teachers with the use of online games that pupils play outside of the lesson. Two EEF evaluations have suggested that this integrated approach has a positive impact on attainment in mathematics.[11,12]

It is also important to consider what technology might replace when attempting to assess its impact. The best judgment of a new technology comes from asking 'Has it had a greater positive impact than the alternative?' rather than just 'Has it had an impact?' That is why the best evaluations of technology compare the intervention with a group that continues with 'business as usual' practice.

Often the evaluated technology is simply no more or less effective than the other types of additional support. For example, GraphoGame Rime, a computer game designed to teach pupils to read, was evaluated by the EEF on struggling Year 2 readers. The evaluation found no difference between intervention and control pupils, but pupils in the control group were receiving other literacy support, including small-group and one-to-one literacy activities.[13]

In these cases, schools must consider which approach is right for them, taking into account a range of factors that may make one approach more compelling than another. For example, if it is well-designed, a technological approach may be associated with reductions in teacher workload. Conversely, in some cases technology might be an expensive way to achieve an outcome similar to that which could have been obtained with a simpler alternative.

*"To date, technology has been most effective when it is used to supplement or enhance teaching, rather than to replace it"*

Even when technology is introduced as an additional strategy outside of the classroom, it is valuable to consider whether it will have an unintended and unhelpful impact on existing activity.[14] For example, it is clear that technology engages and motivates some young people, and as a result recommending an online quiz website could lead students to cut back on other forms of revision unless the site was introduced with some guidance about an appropriate mix of revision strategies.

## Prepare for implementation

Once the problem, potential solution, and rationale are clear, the final step before deciding whether to proceed is to consider implementation, and whether your school has the capacity to implement the approach effectively.

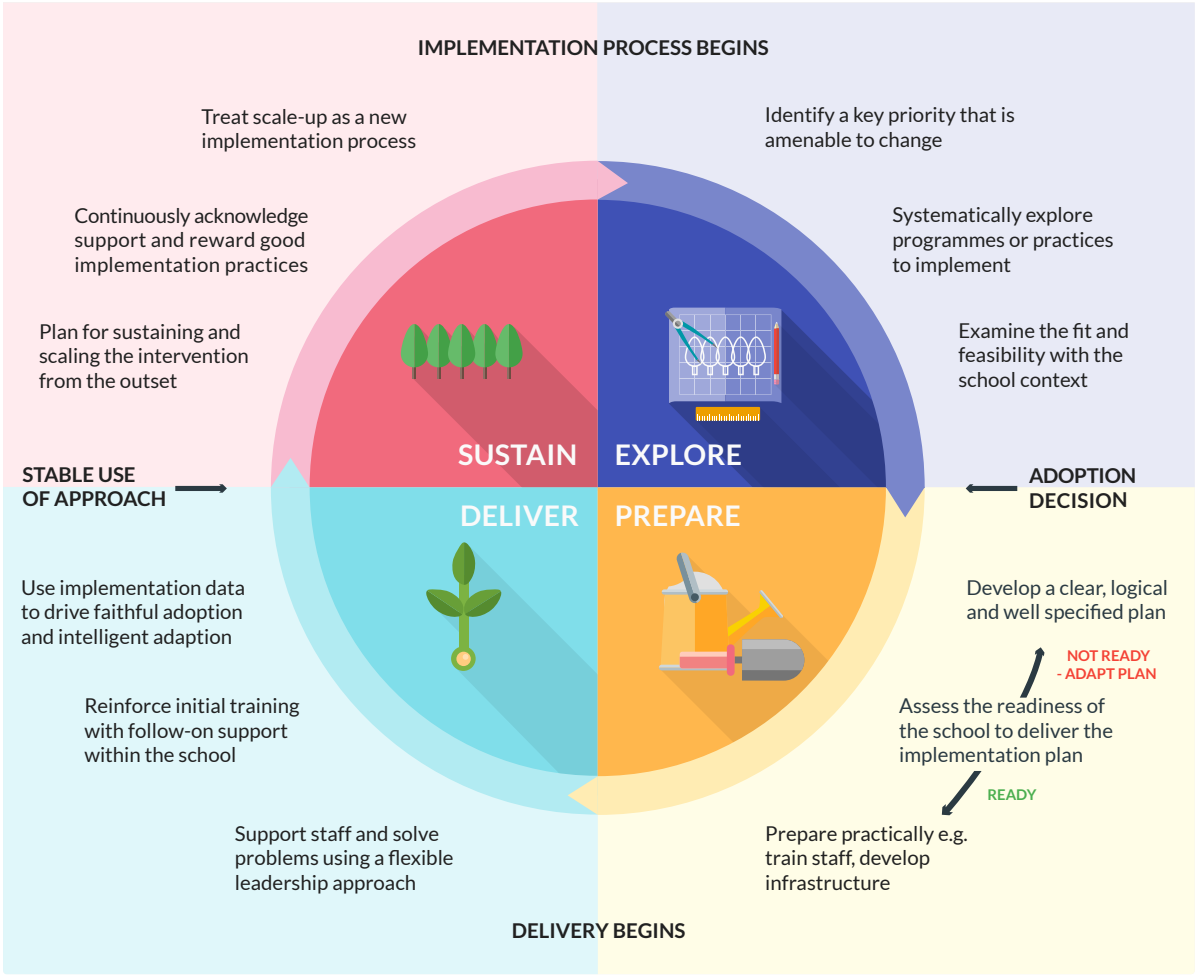
The evidence supports this focus on implementation: approaches that are implemented as intended, including with appropriate training and support for teachers, are more likely to be effective than those that are not.[15,17,18]

The EEF's Guidance Report, *Putting Evidence to Work*, provides more guidance on these implementation considerations (see Figure 1 summarising how implementation can be described as a series of stages relating to thinking about, preparing for, delivering, and sustaining change), and is particularly relevant to technological decisions, which are often poorly implemented.[2]

### Some questions that schools and teachers should consider include:

- Is the right equipment available?
- When should the programme be implemented, and what will the pupils miss?
- What training is required for teachers and teaching assistants?
- What initial support will be required to introduce pupils to the technology being used? Will some pupils need additional ongoing support to use it effectively?
- Is there appropriate space within or outside the classroom for pupils to use the technology?
- Should an adult be on hand to offer support, or will pupils be able to use the technology independently?
- How will delivery of the approach be monitored to ensure that it is used as intended?
- Is there an initial and ongoing financial cost? Is this affordable and justifiable?

**Figure 1: The Implementation Process Diagram**




**First stops for further reading**

- *Putting Evidence to Work: A School's Guide to Implementation*, Education Endowment Foundation (2018).
- *Teachers and Technology: Time to get serious*, Neil Selwyn (2019). Impact: Journal of the Chartered College of Teaching.
- *Buying the right EdTech for your school*, EDUCATE, UCL Institute of Education.
- *Six Myths of Digital Technology*, Education Endowment Foundation (2019). Impact: Journal of the Chartered College of Teaching.

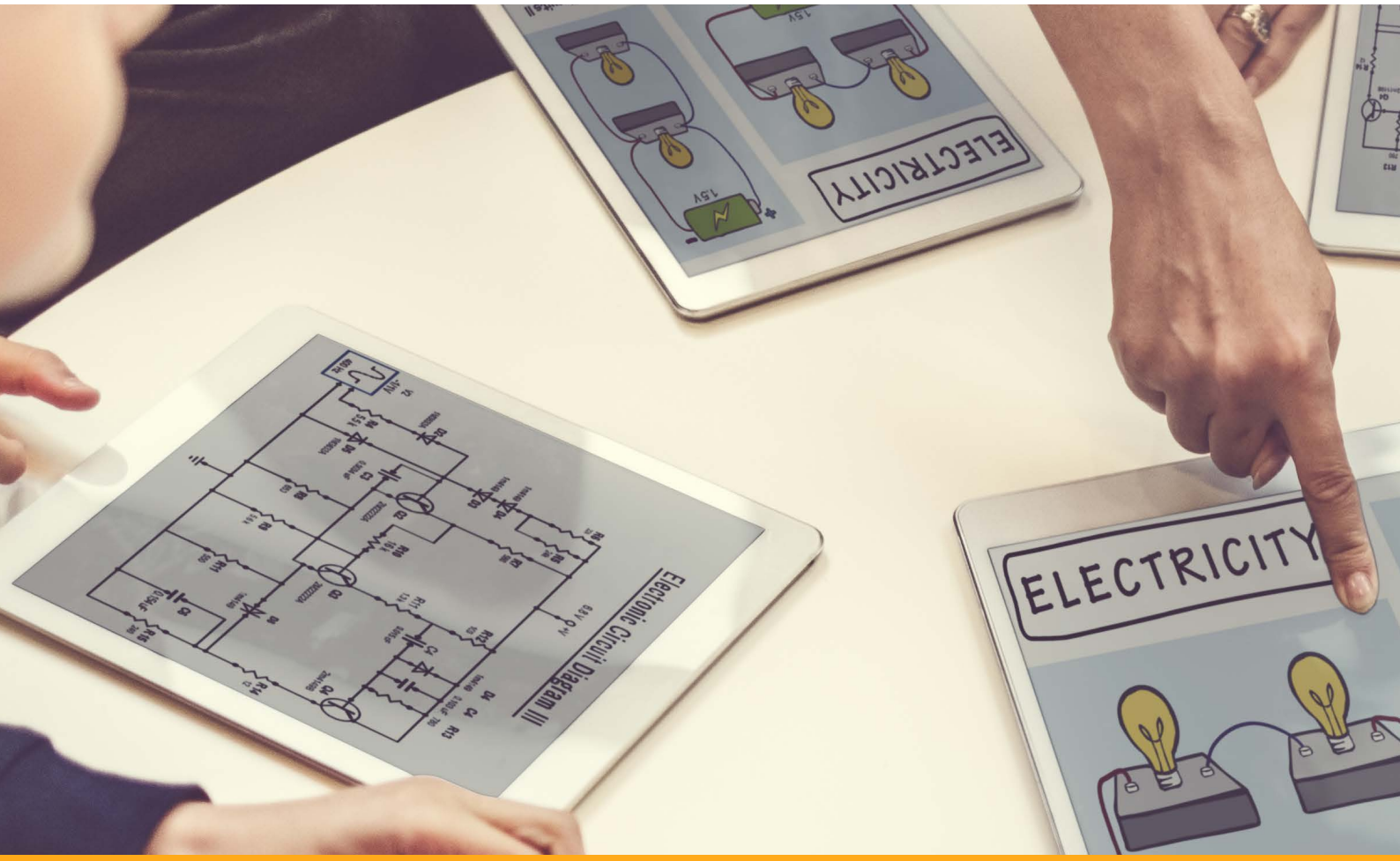
# 2 Technology can be used to improve the quality of explanations and modelling

## Explanations and modelling are elements of effective teaching

Explanations and modelling are the foundations of effective teaching. High-quality explanations and models enable teachers to introduce and explain new ideas, knowledge, and skills to pupils in a way that is accessible, memorable and clear.[19] Explanations and models can take a wide variety of forms. For example, they can be verbal, written, or use physical representations, and be pre-prepared ('Here's one I made earlier') or produced 'live'.

Technology has the potential to enhance the way in which teachers explain and model. Crucially however, the *possible benefits of technology* will be determined by the extent to which it is aligned with the wider pedagogical principles related to explanations and modelling, and *the extent to which these benefits are realised* will depend on the way in which technology is implemented. Simply introducing a new form of technology will not necessarily lead to an improvement in learning (see Box 2).

Effective explanations are likely to involve material being introduced in logical steps, with new ideas being explicitly linked to pupils' prior experiences and knowledge. Good models make abstract ideas concrete and accessible, and can provide an opportunity for teachers to model both what to do and how to think.



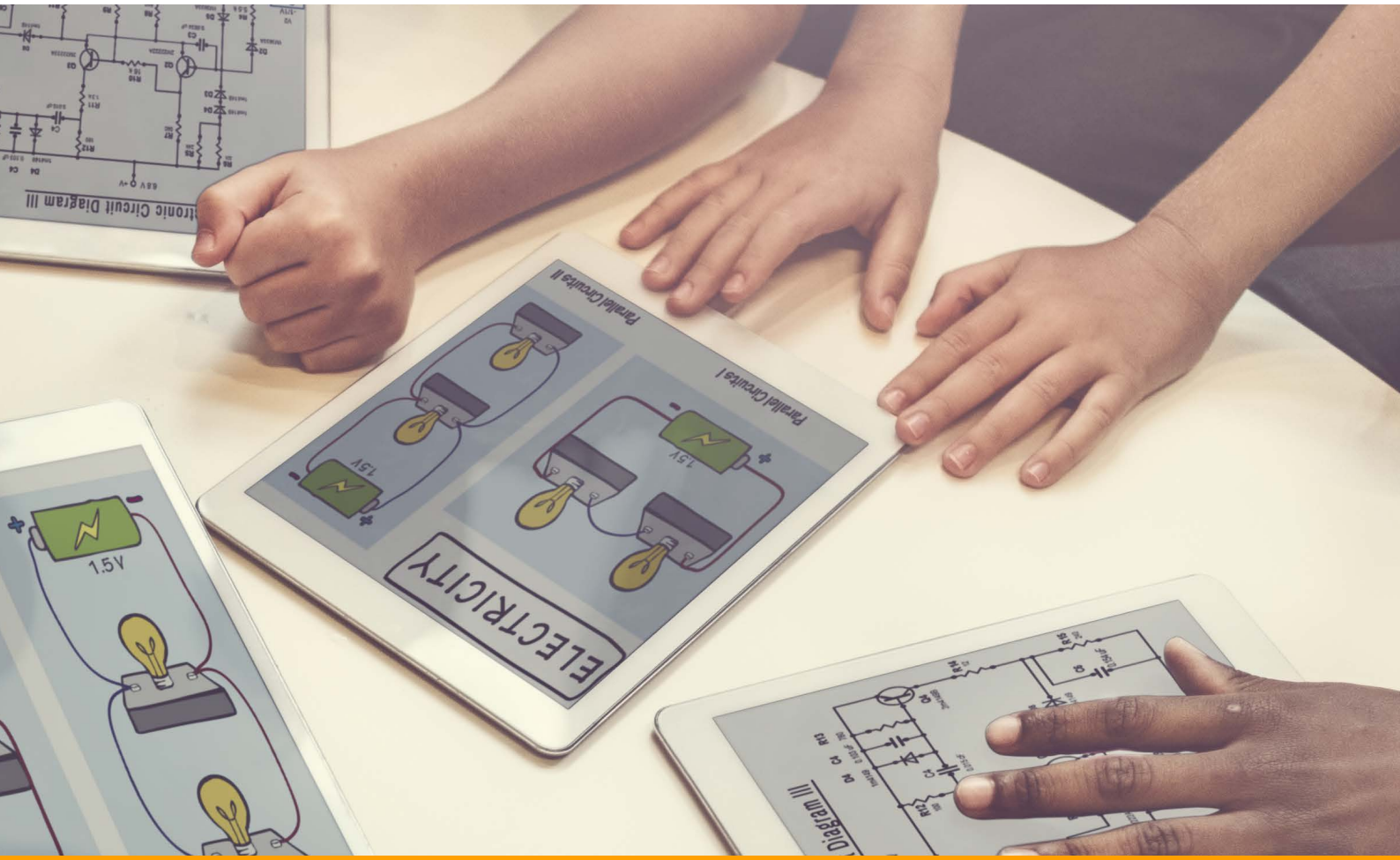
## Box 2: Do interactive whiteboards improve learning?

In the early 2000s, the government funded a large-scale pilot introducing interactive whiteboards to primary classrooms in England. One of the goals of the pilot was to raise attainment in literacy and mathematics, particularly through the use of 'whole class interactive teaching'.[23] Teachers were offered some support and training on how to use whiteboards effectively.

An accompanying evaluation explored the impact on classroom practice and attainment.[24] The evaluation found that whiteboards did change teacher practice – for example increasing the pace of lessons and the number of open questions teachers asked – but these changes were not sufficient to bring about clear improvements in learning. The evaluation found no clear evidence that the attainment in the schools involved in the pilot improved relative to a matched group of similar schools.

Interactive whiteboards were introduced in a large number of schools and are now very common. Not all schools will have provided training and support as in the pilot, so even the shifts in classroom practice observed in the pilot may not have been achieved in other schools.

It could be argued that it was wrong to assume that introducing interactive whiteboards would improve attainment, and there are strong arguments for the other benefits of introducing whiteboards. But this case does provide an example of where an expensive new piece of technology was introduced to the classroom with ambitious aims that do not appear to have been fulfilled.



## Technology can be used to support teachers' modelling and explanations

Technology can be used to help teachers explain and model in a wide variety of ways. More simple examples include using video to introduce new content, or using a visualiser to project worked examples onto a whiteboard. More complex examples might include interactive simulations, or 'flipping' learning so that pupils are introduced to topics at home before they are covered in lessons (see Box 3).

*"More straightforward ways of using technology to support explanations or modelling are less well studied than more complex alternatives"*

Perhaps ironically, more straightforward ways of using technology to support explanations or modelling—such as the use of visualisers—are less well studied than more complex alternatives. However, from those examples that have been evaluated, such as the introduction of interactive whiteboards, it is possible to provide some guidance related to their use.

Two overarching messages relate to the importance of pedagogy and implementation. First, teachers need to understand how the technology will improve their teaching in order for them to be effective; once more, the pedagogy is more important than the equipment. For example, visualisers could improve the quality of explanation and modelling if they enable teachers to show pupils a wider range of high-quality models than they would otherwise be able to, or if teachers use the visualiser to increase the precision with which they explain worked examples, which has consistently been found to increase learning (e.g. in mathematics).[20]

Second, teachers are much more likely to use technology such as visualisers effectively if they receive training and ongoing pedagogical support, and if school leaders dedicate attention to supporting adoption of the technology. As the introduction of interactive whiteboard shows, even apparently simple forms of technology are likely to require sustained training and support to maximise their impact.

## Simulations and virtual experiments

Evaluations of some more complex ways of using technology to improve explanations and modelling show promise, particularly in STEM (science, technology, engineering, and mathematics) subjects. A number of studies have explored the use of interactive simulations in science and mathematics, for example to simulate how ecosystems change or to depict animal dissections.[21] On average, these approaches have been found to improve learning, particularly when the simulations are designed to direct pupils towards particular learning points and when the content of simulations is reinforced with other forms of content, such as a written explanation. In addition, where feasible, it is recommended that simulations or virtual experiments support hands-on practical work, or 'real' modelling, rather than replacing it.[22]

## Box 3: Flipped learning

Flipped learning is an approach in which pupils are introduced to learning material prior to lessons, usually through online resources. This might include watching video explanations of key concepts or techniques, or completing problems or activities that assess prior learning. Teachers are typically provided with assessment data that enables them to use classroom time differently, for example by targeting support at pupils with particular difficulties or by grouping pupils to support collaborative learning.

Flipped learning has been introduced in a wide range of settings in recent years, particularly in secondary schools and higher education. However, despite its popularity, and a range of theories about why the approach might be beneficial, very few high-quality studies of the impact of flipped learning programmes on pupil outcomes have been undertaken.

An exception to this overall picture is a randomised controlled trial funded by the EEF of a programme called MathsFlip, which sought to improve the mathematics attainment of pupils in Years 5 and 6. Each participating class had a personalised web page that included an area for shared resources, videos and documents, and a space for communication between pupils and teachers. Where pupils did not have access to the internet at home, schools provided lunchtime, before-school and after-school sessions when pupils could complete activities.

The evaluation found that pupils following the approach made the equivalent of one additional month's progress in mathematics, compared to pupils in comparison schools.[25] The technical and professional support provided to participating teachers was identified by the report as a key feature of the project. This underlines the need to devote time and resources to implementation. A further challenge identified by the wider literature is ensuring that all pupils complete the preparatory activities so that time is not wasted in lessons going over this material.[26]

Wider research on flipped learning is still very limited, and this study included plenty of high-quality content and support that is not typical of other flipped approaches. Consequently, it would be valuable to supplement the trial of MathsFlip with more high-quality evaluations, including in other subjects and of the most popular flipped learning programmes.

**First stops for further reading**

- *Learning with STEM simulations in the classroom: Findings and trends from a meta-analysis*, D'Angelo et al (2016). A useful, short summary of a review of the literature on computer-based simulations.
- *Principles of Instruction: Research-Based Strategies That All Teachers Should Know*, Barak Rosenshine (2012).
- *Using Cognitive Load Theory to Improve Slideshow Presentations*, Andy Tharby (2019). Impact: Journal of the Chartered College of Teaching.

# 3 Technology offers ways to improve the impact of pupil practice

## Practice matters

Practice is an essential part of teaching and learning. Ensuring that pupils have repeated and varied opportunities to apply and use new skills and knowledge increases success.[20,27,28] Practice can help by increasing the fluency with which pupils can use skills they have learned or help pupils remember key concepts and ideas. As a consequence, a clear way in which technology could enhance learning would be to increase the quantity or quality of pupils' practice, in the classroom or at home.

## Technology can increase the quality and quantity of pupils' practice

Evidence suggests that teachers can use technology to increase the benefits of practice to improve fluency or retention of information, and that this is likely to have a positive impact on learning.[29]

A simple example of using technology to increase the frequency of pupils' practice might be a quiz application on a mobile phone or tablet that tests pupils on vocabulary in geography or dates in history, to support pupils in remembering key information.

*"Teachers can use technology to increase the benefits of practice to improve fluency or retention of information"*

There is particularly strong evidence related to using technology for practice in mathematics, but there is also evidence related to other subject areas, including English, science, and modern foreign language learning. Approaches studied often involved other elements of instruction including feedback from assessment, so it is difficult to separate the impact solely of the additional practice, but increasing the types and numbers of opportunities to practise using new skills is a key common feature.

A further methodological challenge is to disentangle whether the benefits of using technology to support practice are specifically related to technology, or whether similar benefits might be seen from any type of practice. There is some evidence to suggest that other forms of additional practice, for example through additional small-group tuition, can be as effective as approaches using technology.[30]

One commonly advanced suggestion for why technology might support practice is that pupils might find digital activities more engaging than traditional tasks. However, the relationship between technology, motivation, and achievement is complex. In some cases, pupils might be motivated to use technology, but this motivation may not translate to engagement that leads to learning. A second possibility, and potential risk, is that more motivated pupils are better placed to take advantage of the additional practice opportunities offered by technology than their peers. One review which found that low-achieving students did not benefit from mathematics tutoring systems suggested that students need to have 'sufficient prior knowledge, self-regulation skills, learning motivation, and familiarity with computers' to get the most out of the software —something that students facing disadvantages or starting from a low attainment base may not have.[31]

Understanding the complex links between engagement and achievement is important. Monitoring how technology is being used, including by checking that all students have the skills they need to use it effectively, is likely to reduce the risk that technology becomes a tool that widens the gap between successful learners and their peers.

Technology can also be used to support pupil practice outside of the classroom. For example, the EEF evaluation of Texting Parents found that regular, short text messages to parents—such as prompts about homework completion or revision for an upcoming test—improved attendance and attainment.[32] The improvements were small, but the cost of the approach was very low. EEF's guidance on *Working with Parents to Support Children's Learning* provides further evidence-based guidance on effective communication with parents.[32]

## Adaptive and spaced practice

In addition to providing an opportunity for more practice, some forms of technology build in assessment and attempt to adapt the content of tasks that pupils are asked to complete, in order to provide additional challenge and support.

Perhaps counter-intuitively, some studies have found that programmes with these features have on average been less effective than simpler programmes focused on providing extra practice.[29]

Despite this finding, however, there are examples where adaptive forms of technology improved learning more than similar programmes that did not adapt their content.[33] It is also possible that the lower average effect of adaptive approaches can be explained by the fact that a smaller number of studies have been conducted relative to those evaluating simpler approaches. Overall, the mixed picture appears to underline the importance of care in implementing and monitoring the impact of more complex forms of technology.

An additional way to improve the quality of practice is to consider ways in which technology can be used to support retrieval or spaced practice, or low stakes testing.[34] These approaches build on the insights that we are more likely to remember something if we spread practice over time than something we study in one sitting, even if the total time spent on a topic is the same, and that testing one's ability to retrieve key information—through either self or teacher-led testing—can be an effective way to improve recall.

*"These approaches build on the insights that we are more likely to remember something if we spread practice over time than something we study in one sitting"*

Both involve revisiting a topic after a 'forgetting gap' in order to strengthen long-term memory. Both are well supported by wider educational evidence, and can be facilitated by technology.[35,36] However, it would be valuable to conduct more research into the use of particular applications in schools.

## Box 4: Using digital technology to support struggling pupils

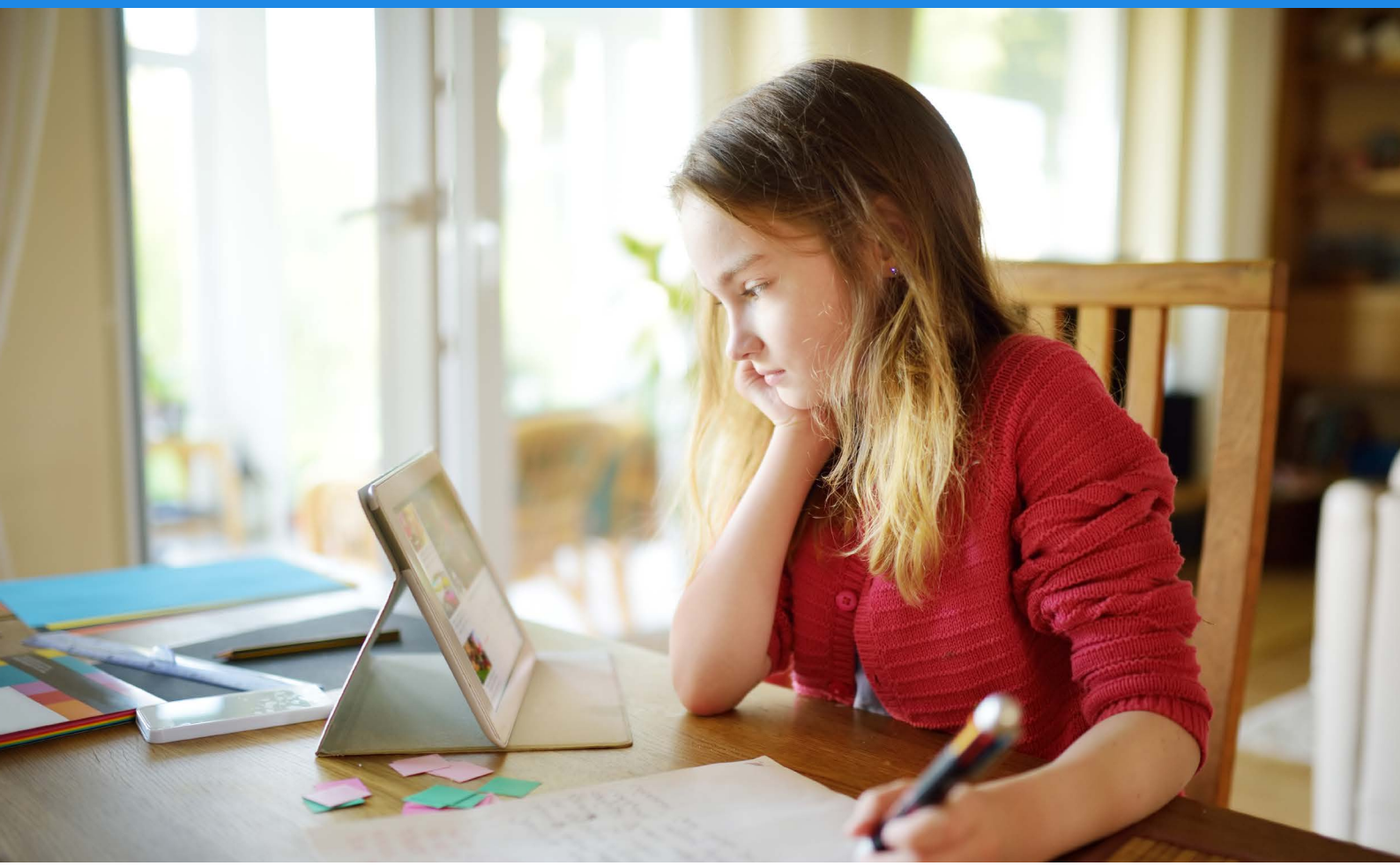
Tutoring systems can provide additional learning opportunities for pupils at risk of falling behind. The appeal is that these programmes offer an opportunity to provide personalised support, something that would be very costly if provided by teaching staff. They often claim to be able to accurately assess pupils' understanding and adapt the content, so that pupils are practising at the right level.

As with other forms of technology, the impact of tutoring systems will depend on how well implemented the intervention is. Effective delivery often requires some level of staff oversight, though a teacher may be able to supervise the individual online practice of several pupils simultaneously.

Most programmes are designed to be used as additional support, replacing other forms of catch-up intervention. In these cases, the evidence suggests that they are unlikely to be more effective than other support, and schools should consider what support is the most efficient and appropriate.

For example, GraphoGame Rime is an academic-developed online reading game evaluated by the EEF.[13] The game provides pupils with the opportunity to practise matching the sound they hear to the correct set of letters ('rimes') on screen, with the complexity of the sounds and rimes matching the appropriate level of challenge for each pupil. The evaluation found that pupils made no additional progress than a control group; however, control group pupils were getting similar literacy support through other programmes and methods.

Similarly, an evaluation of a novel way of making one-to-one tuition more affordable, by delivering online lessons provided by teachers in India and Sri Lanka, found no evidence of an impact.[37] However, control group pupils—who were in Year 6, and identified by their schools as struggling—were also being offered support, sometimes in the form of face-to-face tuition.



**First stops for further reading**

- The Deans for Impact's *Practice with Purpose* report (2016) provides an accessible overview of evidence on the pedagogy of practice.
- *Low-Stakes Testing, Technology and Learning*, Luxton et al. (2019). Impact: Journal of the Chartered College of Teaching.
- *Optimising Learning Using Retrieval Practice*, Sumeracki et al. (2018). Impact: Journal of the Chartered College of Teaching.

# 4 Technology can play a role in improving assessment and feedback

## Assessment and feedback are key elements of effective teaching

Effective assessment provides teachers with information about pupils' learning and needs. It can help teachers judge whether pupils have understood what is being taught, make decisions about whether key concepts and skills have been mastered, and identify which pupils are likely to require additional support.[38] Effective assessment, which can include quizzes and questioning as well as more formal tests, can also help teachers avoid being over-influenced by potentially misleading factors, such as how busy pupils appear, or how confident they claim to be.[39]

*"If technology is used to make assessment more efficient and effective, this can also help to reduce teacher workload"*

In turn, feedback provides pupils with information about how to improve. Like assessment, it can take a variety of forms, and be verbal or written. High-quality feedback is likely to be accurate and clear, encourage further effort and provide specific guidance on how to improve.[40,41] Over time, feedback should also support pupils to monitor and regulate their own learning.

Technology has the potential to improve both assessment and feedback, particularly in terms of speed and efficiency. However, as with other aspects of teaching, the degree to which this potential is realised will be determined by pedagogy and implementation. In particular, how teachers use information from assessments, and how pupils act on feedback, matter more than the way in which they are collected and delivered.

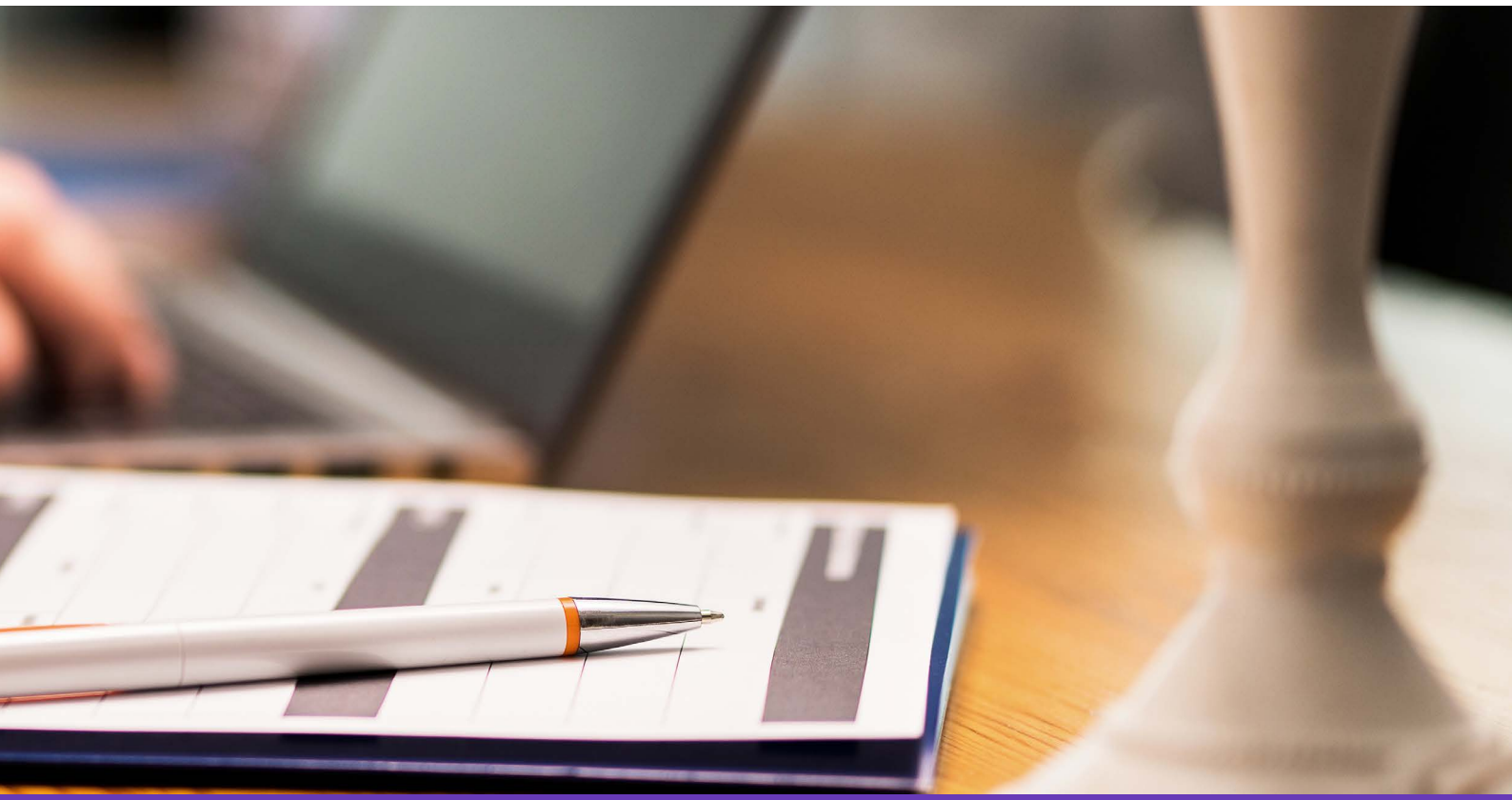
If technology is used to make assessment more efficient and effective, this can also help to reduce teacher workload. Box 5 gives an example of a school changing its approach to providing feedback to pupils that uses teachers' time more effectively.

## Box 5: How one school used technology to improve marking practices

As well as using technology itself providing feedback, some schools have been experimenting with using digital approaches to improve how teachers provide feedback on pupils' work. This is typically done verbally in class, or through written comments, which can take a long time for teachers to write and may be difficult for pupils to act on.

St Margaret's CE Primary School in Withern, Lincolnshire, has developed an approach using tablet computers to record verbal feedback over videos of annotations of pupils' work. The oral element is designed to overcome 'the abstraction between what the teacher intends, and what the pupil understands' in written feedback. The pupils get two improvement points, with a photo of their own work side by side with a photo of a model text. Then, when improving their text, pupils can replay the teacher's voice as often as they like. Unlike other modes of delayed feedback, the only intended audience is the pupil, so the feedback is focused on their needs and moving their learning forward.

The school was experienced in using tablets so the introduction of the approach was smooth, though they still undertook a small randomised controlled trial to assess its impact. This suggested that it was successful, and with some unintended beneficial consequences, such as some pupils with special educational needs and disabilities finding that the headphones enable them to block out distractions while being reassured by their teacher's voice.



## Technology can be used to support effective assessment

Technology can be used to support assessment in a wide variety of ways, aiming to improve either the quality of information collected or the speed and ease with which it is collected. Commonly used examples include using online tests to provide baseline assessment of pupils' literacy skills, or to automatically mark multiple choice quizzes. Other examples include the use of devices or 'learner response systems' to provide teachers with immediate information in lessons about how pupils answer questions. Many programmes for pupils also involve an assessment element alongside video explanations or practice questions.

*"There is little point in the teacher getting immediate, accurate information unless they use it to adapt their teaching accordingly"*

But the important part of assessment is what happens next; there is little point in the teacher getting immediate, accurate information unless they use it to adapt their teaching accordingly.

For example, while a common 'analogue' way to collect a snapshot of pupils' understanding mid-lesson is the use of mini whiteboards held up by individual pupils in response to a class-wide question, technology could be used by teachers to collect the information instead. However, on its own this is unlikely to lead to different results. Instead, the value of this information will be determined by the way teachers use it, which will be informed by, for example, teachers' understanding of common misconceptions within their subject and effective ways to address these.

The results from two EEF trials provide a useful illustration of the idea that technology alone is not enough. The Learner Response System trial looked at the regular use of hand-held electronic clickers in Key Stage 2 mathematics lessons in 2014–16.[42] In response to the teacher's questions, pupils could input the answer on the handset and both pupils and teachers receive immediate feedback. The high-quality study found no impact on Key Stage 2 results, and some concerns on the part of teachers about the accuracy of the feedback (for example, the system providing negative feedback when the answer was wholly or partially correct).

Another EEF study looked at the impact of an 18-month-long, school-wide approach to developing teachers' formative assessment skills.[43] The Embedding Formative Assessment project involved teachers from across secondary schools meeting monthly to be introduced to assessment and feedback strategies they could try in their lessons, many of which could be done technologically, but the focus was on how to use effective and ongoing support to embed the approaches into teachers' practice. This study suggested that this focus on ongoing professional development made a small but cost-effective improvement to GCSE results.

## Technology can be used to provide feedback to pupils

Many technological interventions are designed to provide feedback to pupils following practice questions or games. In theory this type of feedback, often provided as part of 'intelligent tutoring systems', might be preferable to alternatives because of its speed and personalisation, for example if it provides pupils with immediate information about where they went wrong, and offers new problems that focus on these errors.

However, as with all uses of technology, success will ultimately be determined by the quality of the pedagogy underpinning a programme's design, and the way in which it is implemented.[44,45]

Demonstrating this challenge, a number of evaluations of programmes that aim to undertake accurate assessment and provide tailored feedback have not been found to lead to improvements in pupil outcomes compared with normal teaching. One digital programme that has some encouraging evidence is Accelerated Reader, which quizzes pupils on their reading to accurately identify books at the right level of challenge for them. An EEF study found that Year 7 pupils using the programme made more progress than the control group.[46] It was a small study but builds on promising, but mixed, evidence from the United States.[47] The varied results underline the need to implement and monitor the impact of more complex forms of technology with care.

*"Success will be determined by the quality of the pedagogy and the way in which it is implemented"*

Effective use of software also often still relies on some support from teaching staff, even if just to encourage pupils to concentrate on it. There is evidence that guidance from a teacher or teaching assistant can make the impact greater that it would have been otherwise.[48] At the very least, teachers will need to monitor pupils' use and progress, and adjust their classroom teaching accordingly. This can be made easier by some software programmes that offer, for example, dashboard analytics of pupils' progress.

**First stops for further reading**

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# HOW WAS THIS GUIDANCE DEVELOPED?

This guidance draws on an EEF-commissioned review that looked at meta-analyses (a statistical review combining findings from multiple studies) published since 2012, undertaken by Professor Cathy Lewin and Andrew Smith at Manchester Metropolitan University (forthcoming).

The guidance also builds on an earlier review by Professor Steve Higgins and colleagues at Durham University, which looked at meta-analyses published between 1990 and 2012.[1]

Where possible, we have provided examples and lessons from the most recent, robust and relevant studies, as well as real-life case studies of schools applying the recommendations in practice.

## NOTES

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