PERSPECTIVES ON TECHNOLOGY, RESOURCES AND LEARNING

PRODUCTIVE CLASSROOM PRACTICES, EFFECTIVE TEACHER PROFESSIONAL DEVELOPMENT

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Executive Summary

An effective, high-quality education system is of central societal importance. Educational institutions are embedded in society, and educational practice is shaped by various factors, including norms and values, government policy, the overall availability of resources (including content and technology), as well as research evidence for effective teaching and learning.

For several decades, advances in digital technology have led to an increased interest in considering its potential applications in the education sector. More recently, the increased affordability of low-cost mobile technology has sparked intense interest and experimentation in the classroom. This experimentation is often characterised by a specific narrow focus (for example, on the technology itself), rather than considering: (i) the wider connections between technology and pedagogy; (ii) what constitutes effective technology-enabled learning environments for children (in the classroom); (iii) corresponding teacher professional development opportunities.

In this report, we offer six wider perspectives on the interaction between technology, pedagogy, and educational resources. **The implementation of technology in the classroom** cannot be seen as a one-off process, and a pragmatic Design/Engineering-Based Research approach offers a means of iteratively developing robust designs that can be sustainably implemented in classrooms. **Lessons for the successful introduction of technology in schools** include technology management and appropriate infrastructure. Holistic strategies for integrating digital and nondigital resources are needed, and teacher professional development (TPD) needs to be aligned with a shared vision across all stakeholders. Indeed, pedagogical practice is not an outcome of technology use, and does not simply change as a result of introducing new technology. **Pedagogic spaces must be opened up** to promote student dialogue, collaboration and problem-solving activities. This can be supported by a broad range of hardware and software used in conjunction with nondigital tools and resources.

The teacher and teacher education are central for the successful integration of digital technology into the classroom. Pre-service and in-service education, including lifelong learning, needs to build in technology experiences, with a view to developing the knowledge and confidence of teachers. In relation to the use of **mobile technology in international development**, many ICT-based education projects still have a narrow focus on hardware and software. Educational research shows that resource-based interventions alone have limited impact on student learning, and that technology in itself does not add value to education. As with more developed educational systems, interventions that combine resource-based interventions and teacher development stand the best chance of success. In many low-resourced countries, teachers urgently need more effective opportunities for professional development in order to meet children's need for better education. Children urgently need more effective teachers, not more gadgets in the classroom, particularly when funding and

resources are limited. **Educational content** needs to be (culturally) appropriate for students and student learning, for instance with regard to the curriculum and teachers' pedagogies. Content must also support teachers and, where needed, include content for teacher development programmes. To ensure sustainability and scalability, content should be freely available, as Creative Commons-licensed Open Educational Resources (OER).

The aim of this report is to build bridges between technology industries and recent educational research evidence, with a view to supporting the development of more effective, technology-enabled learning to which both educators and technologists can aspire. We consider the connections between technology and pedagogy, with a particular focus on what constitutes effective technology-enabled learning environments for children (in the classroom), and corresponding TPD opportunities.

Each of the six perspectives outlined above draws on key messages from rigorous educational research, including landmark literature reviews, enriched with examples based on the authors' personal experiences. We note that the overall evidence suggests that education outcomes are not about the technology itself, but instead, about ***how*** technology is used. Key messages emerging from the research literature provide a basis on which pedagogical innovation can inform future directions, and ultimately lead to higher quality learning outcomes. To future-proof the perspectives provided in this report, we conclude with a toolkit for discussion.

THE TEACHER AND TEACHER EDUCATION ARE CENTRAL FOR THE SUCCESSFUL INTEGRATION OF DIGITAL TECHNOLOGY INTO THE CLASSROOM.

Key points from the perspectives

Perspective 1 – Implementing technology in the classroom: a blueprint for a pragmatic engineering approach to research and development

- The impact of technology in schools has often been limited as a result of reformers not fully appreciating the nature of appropriate pedagogy and teaching practices.
- Design-Based Research (DBR) is a research and development approach that involves the iterative development of robust designs that can be sustainably implemented in classrooms.
- Engineering-Based Research (EBR) is a variant of DBR concerned with systemic change (for instance, classroom practices, systems and structures). EBR provides an excellent methodological solution for collaborative design and development involving schools, researchers and technology.

Perspective 2 – Lessons for the successful introduction of technology in schools: technology management, appropriate infrastructure and overcoming other barriers

- Technology is most effective when there is an holistic strategy to integrate digital and nondigital resources; the school's infrastructure needs to facilitate the use of the technology being introduced.
- A number of school-level barriers can impede the successful integration of technologies. Teacher Professional Development (TPD) that is aligned to a vision shared among all stakeholders and encouraged at all levels is most likely to be successful in overcoming such obstacles.
- Interactive pedagogy is not an outcome of technology use, and does not simply change as a result of the introduction of new technology. Instead, the power of using technology in the classroom relies on the premise that it is integrated into existing pedagogy.

Perspective 3 – Opening up a pedagogic space to promote student dialogue and collaboration: moving beyond the affordances of hardware to enhance learning outcomes

- Enabling teachers to make strong connections between their pedagogy and their intended use of technology in the classroom has a powerful impact on the way in which these technologies are used for students' learning.
- One challenge for producers of computing hardware and software is to envisage relevant problem-solving activities for materials that set activities in a meaningful context for students.
- A focus on curriculum subject learning alone, without due consideration of how collaboration,

problem solving and dialogue develop students as learners, is likely to lead to technology use that does not necessarily improve learning outcomes.

- Some of the most interesting, and arguably effective, examples of educational technology use in schools do not focus on the use of a single application, but use a broader range of hardware and software in conjunction with nondigital tools and resources.

Perspective 4 – The central role of teacher education for the successful integration of digital technology into the classroom

- Teachers' adoption of technology is influenced by the quantity, and quality, of pre-service technology experiences. Teacher education programmes should not simply focus on how to use technology, but should instead address how technology can be used for teaching and learning.
- In-service TPD prepares teachers to be able to develop, adapt and deliver appropriate curricula that promote learner progress. Without appropriate TPD, genuine pedagogical transformation facilitated by technology is unlikely to occur.
- Effective TPD, which forms a continuum from pre-service to in-service and lifelong professional learning, requires an integration of discipline expertise, pedagogical expertise and ICT competence.

Perspective 5 – Mobile technology and international development

- Many ICT-based international development education projects have a narrow focus on hardware and software.
- Education research shows that resource-based ("access") interventions alone have limited impact: technology in itself does not add value to education.
- Children, particularly disadvantaged children, urgently need better teachers. Given limited funding and the need for equitable access, resources need to be focused on what works (interactive teaching practices and TPD).

Perspective 6 – The role of educational content

- Content needs to be appropriate for students and student learning (in terms of culture, curriculum and pedagogy).
- Content needs to support teachers (content provides classroom use cases; content includes materials for school-based teacher development activities).
- To ensure equity, sustainability and scalability, content should be open (Creative Commons-licensed).

The promise of digital technology

Digital technology, as a class of tools to support teaching and learning, offers seemingly endless possibilities for information retrieval, manipulation, creation and presentation, in addition to communication and the introduction of new ideas in education. Despite recent technological advances and teachers' efforts to take advantage of digital technology, there has been a surprising shortfall in its far-reaching impact envisaged by some on classroom practice (OECD, 2015). Indeed, classroom practice often does not appear to fully utilise the potential of digital technology, nor to capitalise on many young people's extensive use, and experiences with, technological tools outside of the classroom (Gillen et al., 2007; Rasmussen and Ludvigsen, 2010).

Since the early 1980s, schools, colleges and universities have experimented with technology for learning (Sharples et al., 2010). Just over a decade ago, Wagner et al. (2005) asserted that simply putting computers into schools is not enough to positively impact student learning. Today, however, educational technology initiatives are still being launched with little regard for the classroom practices employed by teachers to support learning, and indeed with little regard for pedagogy. The notion of pedagogy is more than a simple collection of the methods and practices of teaching; it incorporates the complex relations between teacher and learners, the learning context, the teacher's subject knowledge and purposes, the teacher's view of learning and how to support it, the selection of learning and assessment activities, learning about learning, and learner characteristics such as age, stage and knowledge (c.f. Watkins and Mortimore, 1999). If educators are to realise the full potential of technology in improving student learning outcomes, it is critical that pedagogy is carefully considered from the outset.

Recently, countries across the world have begun to consider how their education systems can promote twenty-first century skills (for example, the US-based Partnership for 21st Century Learning, or P21). This includes placing a greater emphasis on the potentially "transformative" role of technology used to support educational activities. Research has consistently demonstrated that appropriate computer support (see first bullet point below) can facilitate students' sustained attention and engagement (Beauchamp and Hillier, 2014; Wegerif, 2007). The 'Mode Dimension' of the Computer Practice Framework (Twining, 2008) identifies three categories of impact that using ICT as a 'learning tool' might have on student engagement. Definitions of these categories, which focus on the extent to which using ICT as a 'learning tool' changes what is taught (the curriculum) and/or how it is taught (pedagogy), and whether or not these changes can be achieved without ICT, are as follows:

- **Support**: Learning objectives remain the same, but the process is automated in some way. Therefore, the support that ICT offers is about improving efficiency and effectiveness without changing curriculum content. The use of 'drill and skill' software or an 'integrated learning system' (ILS) falls into this category.

- **Extend**: Curriculum content and/or process are different due to the use of ICT, but these changes could take place in a classroom context without a computer or related ICT. For example, teaching students how to teach other students to use some software is easier when they have been previously taught how to act as peer tutors in other contexts.
- **Transform**: Curriculum content and/or process are different, and these changes could not have taken place in a classroom context without a computer or related ICT. If children use multimedia authoring software to represent their ideas using images, video, text and hyperlinks, then they are probably operating within the Transform category.

A related model — the increasingly popular SAMR model (substitution, augmentation, modification, and redefinition, see Figure 1) — has also been developed. The model encapsulates the challenge (for technologists, teachers and researchers) to move technology use away from simply enhancing learning to become genuinely transformative by modifying and redefining pedagogical practice (Puentedura, 2014).

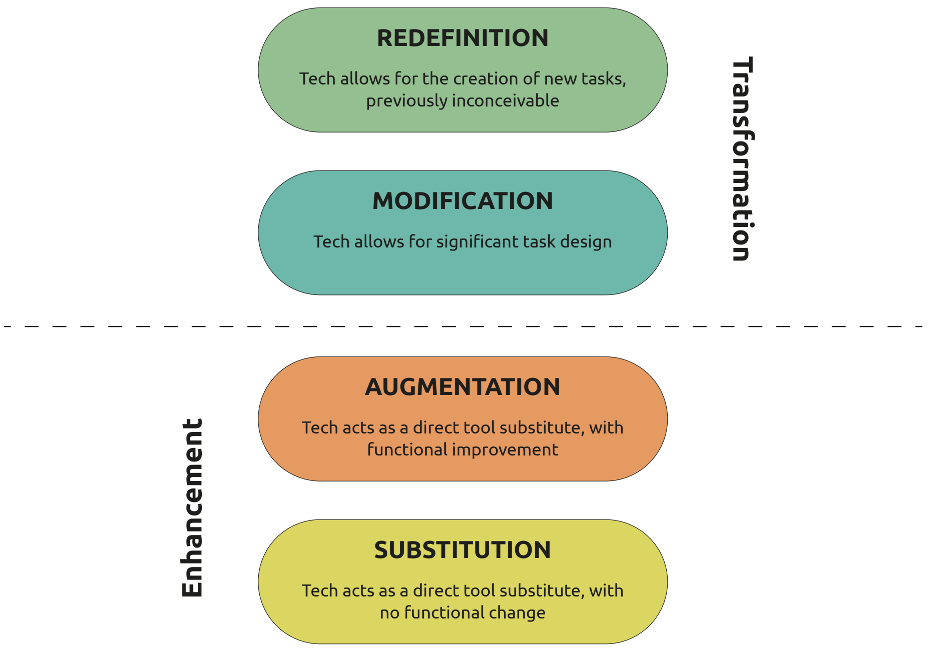

Figure 1: The SAMR model (Puentedura, 2014)

To illustrate, consider the use of tablets in a high school setting with students aged 14. One class of students is using their devices to write a short story of 250 words. At the same time, students in another class are creating a comic book using a dedicated app and the tablet's camera. Consider which of these examples is likely to be indicative of a 'substitution' task (that is, a learning activity that would or could be normally carried out using pen and paper) and which is an example of a 'redefinition' task (where there is no suitable direct alternative for facilitating the learning activity).

Another useful framework is the UNESCO ICT Competency Standards for Teachers (CFT, UNESCO, 2011), which considers teachers' development of technology use in six areas (understanding ICT in education; curriculum and assessment; pedagogy; ICT[1]; organization and administration; teacher professional learning) at three levels (technological literacy; knowledge deepening; knowledge creation). The framework is useful in drawing out different competencies that teachers should have for meaningful technology use, and helps teachers to understand and progressively deepen their approach to using ICT. However, we argue that the framework should not be construed as a curriculum for TPD, in which teachers simplistically pass through three consecutive stages. Each teacher brings their own background knowledge, previous skills and experience, and may already be a "model learner", capable of "complex problem solving" (at the knowledge deepening / creation stage; c.f. ***ibid.,*** p. 3). Even if such a teacher had only basic ICT skills, they should not have to first consider "didactic teaching and ICT" (technology literacy, Module 3, Pedagogy, ***ibid.,*** p. 24), but should instead be encouraged to integrate ICT within their existing pedagogies. Another problem arises if the CFT is construed as a curriculum for TPD seeking to address equitable, quality Education for All, since the six areas are not equally important: emphasis arguably needs to be given, for instance, to pedagogy (impacting on equitable quality learning), rather than to understanding ICT (as a technology).

A UK-based independent charity, the Education Endowment Foundation (EEF), works to raise the attainment of children by funding and evaluating educational innovations to extend and secure the evidence on what works (and what can be made to work at scale). The EEF provides a high-level overview[2] of various interventions, paying attention to the learning gains, the security of the research evidence for those learning gains, and the associated costs (per pupil).

We note the (perhaps obvious) fact that while some programmes have strong measurable learning gains,[3] others have no measurable impact on learning.[4] In some circumstances, technology use may even contribute to negative learning outcomes (for example, one group

1 ICT here means knowledge about ICT (as such).

2 EEF Toolkit, http://educationendowmentfoundation.org.uk/toolkit/

3 Examples: The Mathematics and Reasoning programme evaluation provided evidence that there was "a positive impact on pupils' numeracy ability". Moreover, there was "an association between greater use of the accompanying computer games and greater impact in the numeracy intervention, suggesting the computer games were important to successful implementation".

https://educationendowmentfoundation.org.uk/evaluation/projects/improving-numeracy-and-literacy-in-key-stage-1/

The Self-Regulation to Improve Writing programme evaluation found that the approach had a "strong positive effect on the writing outcomes of low attaining pupils at the transition from primary to secondary school".

https://educationendowmentfoundation.org.uk/evaluation/projects/using-self-regulation-to-improve-writing/

4 Examples: The Rapid Phonics programme evaluation found "no positive effect size […] for the primary outcome of reading comprehension". The intervention used "books (some in e-book format), posters and worksheets".

https://educationendowmentfoundation.org.uk/evaluation/projects/rapid-phonics/

The Shared Maths programme evaluation did "not provide any evidence that the […] programme had an impact on attainment in maths, when used with Year 5 and 3 pupils".

https://educationendowmentfoundation.org.uk/evaluation/projects/shared-maths/

of teachers found learning outcomes to be inferior when tablets were used to support collaborative tasks that aimed to enhance student creativity and writing skills, compared with non-technology based tasks that were completed during previous academic years; Culen and Gasparini, 2012).

We also note that while the research evidence for some programmes is strong, for others it is weak. Indeed, the relatively limited and fragmented nature of the current knowledge base can make it difficult to draw general conclusions about the potential of technologies that can be used for educational purposes (Haßler et al., 2015). Weak evaluations are often short-term rather than long-term and comprehensive. Research (especially in pilots) may be limited to specific qualitative aspects. However, even in large-scale, well-funded programmes, there is often a sole focus on quantitative research, providing evidence for learning gains, without any insight into the processes that led to such learning gains. While relatively few projects employ mixed methods research (that is, research that involves both qualitative and quantitative aspects), there is little doubt that (in principle) educational technologies can viably be used to support school children of all ages to learn in a variety of settings (ibid).

Research conducted for the EEF (see Higgins et al., 2012) has identified that digital technology is currently associated with moderate learning gains across age groups and for most of the curriculum (on average an additional 4 months, although there are considerable variations in impact). Additionally, the EEF identifies the cost of investing in new technologies as being relatively high (although it is recognised that such technologies are a part of the society we live in and that virtually all UK schools are already equipped with computers and interactive whiteboards): expenditure is estimated at a one-off cost of £300 per pupil for equipment and technical support, and a further £500 per class (£20 per pupil) for teacher professional development (TPD).

Perhaps the most significant element of the EEF's digital technology summary is the conclusion that the effective use of technology is driven by learning and teaching goals, rather than by specific technologies driving learning outcomes. This conclusion resonates with decades of research in the field that makes the same point. Technology is subordinate to pedagogy, and supplements or enhances other teaching (as opposed to replacing more traditional approaches). Introducing new technology on its own does not lead to increased attainment. Moreover, motivation to use technology does not always translate into more effective learning, particularly if the use of the technology and the learning outcomes are not closely aligned (Haßler et al., 2015).

In developing regions (such as sub-Saharan Africa (SSA) and South-East Asia), challenges to providing quality Education for All are exacerbated by the prevalent low-resource contexts, and raising quality in primary education is a key concern for the post-2015 development agenda (UNESCO, 2014). Education programmes are often developed in isolation, without drawing on established evidence for educational effectiveness. This results in a "perpetual state of piloting", rather than the development of coherent, sustainable, large-scale impactful programmes. Digital technology use in schools, often considered a "solution", is thus having limited impact. However, there is a growing desire from Ministries of Education in SSA to utilise technology to promote quality learning, as well as a growing awareness in the mobile technology sector, and appropriate strategies are emerging. This report offers key messages for raising the quality of teaching and learning in developing regions, highlighting the central role of the teacher, teacher education opportunities, technology and educational content.

Perspectives: Facilitating the transformation of technology use in schools

Perspective 1

Implementing technology in the classroom: a blueprint for a pragmatic engineering approach to research and development

Perspective 2

Lessons for the successful introduction of technology in schools: technology management, appropriate infrastructure and overcoming barriers

Perspective 3

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1

Perspective 1

Implementing technology in the classroom: a blueprint for a pragmatic engineering approach to research and development

There is a vibrant history of attempts to reform classroom practice long before the introduction of computers, mobile devices and interactive whiteboards. Cuban's (1993) classic historical analysis of classrooms over a 100-year period reveals the constraints that shape practice, establishing that teaching tends to follow traditional routines and patterns as a result of resource limitations. Traditional practices and pedagogies are a practical solution to the demands of teaching that are sustained through apprenticeships of observation (Lortie, 2002). Stigler and Hiebert's (1999) analysis of practice supports the view that traditional routines are sustained and shared within cultures.

THE IMPACT OF TECHNOLOGY IN SCHOOLS HAS OFTEN BEEN LIMITED AS A RESULT OF REFORMERS NOT FULLY UNDERSTANDING THE NATURE OF APPROPRIATE PEDAGOGY AND TEACHING PRACTICES.

The reason why the impact of technology has often been limited is the same reason that reformers have often failed to introduce new ideas and change classroom practice: it is as a result of not fully appreciating the nature of appropriate pedagogy and teaching practices. Indeed, the approaches to changing what is perceived as 'pedagogy' are subsequently misguided.

Teachers' prior values, attitudes and practices may significantly shape their responses to, and experiences of, educational programmes that involve technology (Power et al., 2014). One strategy for change is based on the idea that the practices observed in teachers' classrooms are a result of their perspectives or beliefs about what constitutes effective teaching and learning. This strategy often involves the introduction of new educational approaches being supported by accompanying professional development intended to help teachers in developing new perspectives consistent with the approach being introduced. While appropriate support for professional development is indeed critical, and can help to demonstrate the effectiveness of a new teaching approach in practice, it does not automatically lead to sustainable change. This also applies to the introduction of new technologies: while adoption and implementation might seem to succeed initially, teachers' usage (for example, of a new teaching approach that incorporates technology) can diminish over time, for instance because the original idea (and associated innovative approach) is adapted to fit in with existing practices, or because ongoing support is not provided.

The seminal work of psychologist Ann Brown (1992) offers an alternative method for developing scalable and sustainable approaches to the implementation of new pedagogy in the classroom. In response to the frustrations of translating laboratory results into classroom practice, Brown developed a methodology that she called the 'design experiment'. This involves devising a pedagogical approach (the design) and subsequently trialling it in a real classroom. Data is collected in the form of observation notes and interviews with the teachers and students. Following analysis of this data, theory is developed while simultaneously developing the original design. The importance of this approach is that research and development are undertaken with close reference to practice, often by the practitioners themselves.

This approach has evolved and has become known as Design-Based Research (DBR; Cobb et al., 2003): a research and development approach that uses iterative empirical testing. Through the use of this methodology, we are starting to see the emergence of robust designs[5] that can be sustainably implemented in classrooms. The empirical research also leads to the development and evolution of educational theory.

THE ENGINEERING APPROACH TO EDUCATIONAL DESIGN AND DEVELOPMENT PROVIDES AN EXCELLENT METHODOLOGICAL SOLUTION FOR COLLABORATIVE RESEARCH AND DEVELOPMENT INVOLVING SCHOOLS, RESEARCHERS AND TECHNOLOGY COMPANIES.

Burkhardt and Schoenfeld (2003) have taken this approach further; their Engineering-Based Research (EBR) approach attempts to overcome a number of difficulties with research and development projects. They address issues of funding research and development, the problems of validity and relevance to education, the problems of efficacy of design, and issues of sustainable and scalable implementation. It is this engineering approach to educational design and development that provides an excellent methodological solution for collaborative research and development involving schools, researchers and technology companies. It avoids considerable (and risky) initial investment by formatively testing and evaluating prototypes that have been collaboratively developed, and it provides an opportunity for the input of multiple perspectives in the development process. This method also naturally leads to the production of essential professional development needed to support implementation for later adopters. Like DBR, EBR also permits contribution to educational scholarship.

The main difference between DBR and EBR is one of scale. DBR typically involves looking at an aspect of pedagogy (perhaps within a handful of classrooms) or one aspect of system change. EBR, on the other hand, is concerned with systemic change (including such areas as classroom practices, systems and structures) and involves large-scale collaboration between teams of practitioners, technology providers, researchers and academics. In effect, EBR can be viewed as DBR on an industrial scale. Figure 2 illustrates the EBR process.

5 See: International Society for Design and Development in Education (ISDDE).

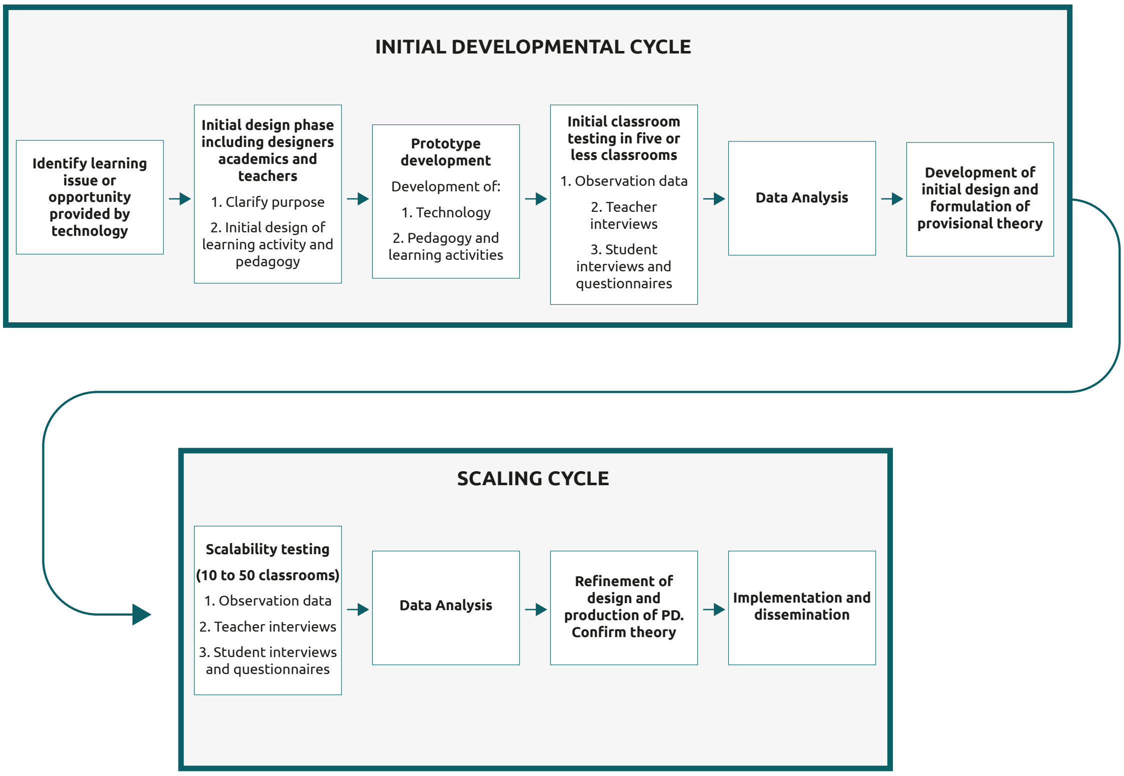

Figure 2. The Engineering-Based Research process

A DBR/EBR approach to developing and implementing technology is an integrated process of delivering sustainable change. Pedagogical developments are introduced through the iterative DBR/EBR process: particularly in the initial design phase (see Figure). What makes change sustainable is that change efficacy is integrated in both the design and scaling phases.

The nature of the iterative process involves evaluating change efficacy, in addition to permitting an understanding of how both teachers and students respond and learn. Of course, learning innovations that have been identified from psychology or other social sciences can be combined with the technological innovations that form part of the initial design stage. A collaboration between technology experts, academics, teachers and students has enormous potential to enhance opportunities for learning and development, thanks to a communion of different perspectives, knowledge, skills in a shared project and enterprise.

2

Perspective 2

Lessons for the successful introduction of technology in schools: technology management, appropriate infrastructure and overcoming barriers

In this perspective, we draw on our experience of evaluating the research literature relating to learning gains from the recent introduction of tablets into schools (Haßler et al., 2015; Major et al., 2016). We offer a number of key messages that can help to guide the successful introduction of educational technologies in educational settings. Effective technology management, underpinned by sound change management principles, is critical to the successful introduction of educational technologies in schools (Heinrich, 2012). An existing technical team may successfully play the role of a change agent (Li et al., 2010), while the cultivation of a supportive school culture that fosters collegiality and teacher empowerment at different levels can be pivotal for the effective introduction of technology (ibid.). Poor management and technological issues have led to the collapse of education technology initiatives previously (Farivar, 2014). Even high profile schemes, such as the $1 billion Los Angeles School District iPad initiative (BBC News, 2015), have been affected by a number of significant challenges. Therefore, development of rigorous contingency plans from the outset is essential for school-based education technology projects.

TECHNOLOGY IS MOST EFFECTIVE WHEN THERE IS AN HOLISTIC STRATEGY TO INTEGRATE DIGITAL AND NONDIGITAL RESOURCES.

When assessing their investment in technology, educators should also acknowledge that this is most effective when there is an holistic strategy to integrate digital and nondigital resources. The school's infrastructure needs to facilitates the use of the technology being introduced (Diaz et al., 2014). For example, when introducing tablet computers in schools, schools must ensure that they have a robust wireless infrastructure with sufficient capacity to accommodate entire class sets of devices connecting simultaneously (Sheppard, 2011; Ward et al., 2013). The make/model (and operating system) of tablets and laptops chosen may have implications (for example, with regard to open source options; Sheppard, 2011). In addition, new or updated models may be released midway through implementation (Culen and Gasparini, 2012), and the school may occasionally need to purchase supplementary equipment (such as VGA display adapters; ibid.). Tablets (and potentially other educational technologies) present specific challenges to younger children who can experience difficulty in handling devices (although external cases with handles may help to remedy this; Furio et al., 2013). An important question is whether students have access to devices outside school (Carr, 2012); giving students continuous access to the implemented technology outside of the classroom may help to improve learning outcomes. This premise also underpins the 'One Laptop Per Child' scheme (Adam, 2015; and references therein).

A number of other school-level barriers can impede the successful integration of technologies, including lack of time, lack of effective TPD and lack of appropriate technical support (Bignimlas, 2009). TPD that is aligned to a shared vision and encouraged at all levels is most likely to be successful in overcoming such issues. Schools rarely take into account — or budget — for the additional TPD and support costs which are likely to make the difference to how well the technology is used, while teachers need support and time to learn to use new technology effectively (Higgins et al., 2012). This involves more than just learning how to use the technology; it should include support for understanding how it can be used in subject learning. Indeed, schools should not assume that teaching staff are able to use technology effectively for educational purposes from the outset (Melhuish and Falloon, 2010), but should proactively create adequate opportunities for professional development. A lack of relevant TPD, a shortage of technical support and the absence from school policy of encouragement of the use of a particular technology can all prevent staff from using new technologies on a regular basis (Oliviera, 2014). In other words, technical support should form part of the Engineering-based Research (EBR) dialogic process.

TPD THAT IS ALIGNED TO A SHARED VISION AND ENCOURAGED AT ALL LEVELS IS MOST LIKELY TO BE SUCCESSFUL IN OVERCOMING SUCH ISSUES.

Therefore, it is essential that technical support is provided, particularly to teachers (and school technical support staff) charged with introducing technology. New educational interventions require time to become embedded in classroom practice; school leaders (and other stakeholders) need to acknowledge that the benefits of a new technology are not immediate (Carr, 2012; Silvernail and Gritter, 2004). Indeed, there is a well-established need to engage the support of school leadership for successful implementation of educational technology interventions (e.g. Power et al., 2014).

Finally, pedagogical practice is not an outcome of technology use, and does not simply change as a result of introducing new technology (Osborne and Hennessy, 2003). On the contrary, the power of using technology in the classroom relies on the premise that technology is integrated into existing pedagogy (Hennessy and London, 2013). Teachers have previously been able to use technology to modify and redefine student learning by employing transformative pedagogical models, with technology acting as a catalyst for more creative pursuits and exploration of new pedagogical approaches (Goodwin, 2012). As discussed in Perspective 4, the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler and Mishra, 2006) is relevant to technology use, and teachers have successfully applied their TPACK to choose how to implement devices such as tablets (Cumming et al., 2014). However, a rethink of the pedagogical approach is necessary in order to take into account new opportunities that may arise (such as multimodal interactions and collaborations between students using tablets collaboratively; Culen and Gasparini, 2012). For example, consideration must also be given to the usage ratio of devices to students. While it is sometimes taken for granted that 1:1 settings (that is, one tablet per student) are most effective, there is no conclusive research evidence to support this. Indeed, sharing one tablet between two or more students as part of collaborative learning appears to be effective for improving student learning outcomes (Haßler et al., 2015). Given the established evidence for learning gains from collaborative learning, this is hardly surprising.

THE POWER OF USING TECHNOLOGY IN THE CLASSROOM RELIES ON THE PREMISE THAT TECHNOLOGY IS INTEGRATED INTO EXISTING PEDAGOGY.

3

Perspective 3

Opening up a pedagogic space to promote student dialogue and collaboration: moving beyond the affordances of hardware to enhance learning outcomes

Research shows that students who are taught dialogic skills perform better in critical thinking, collaborative problem solving and reading comprehension (Howe and Abedin, 2013; Kuhn, 2015; Lawrence and Snow, 2010; Mercer, 2013). There is robust evidence (Mercer et al., 2004; Rojas-Drummond, et al., 2003) that demonstrates that *"the quality of classroom talk has a measurable impact on standards of attainment in English, mathematics and science"* (Alexander, 2012, p. 1). Indeed, the quality of classroom discussion is an important predictor of students' learning (Gamoran and Nystrand, 1991; Murphy et al., 2009).

Classroom dialogue, and a pedagogy that promotes it, is about more than 'just talk' (Cazden, 2001; Myhill et al., 2006): dialogue is language use that enables people to 'interthink' (Mercer, 2000) and come to an understanding of one another's knowledge and perspectives. As Flitton and Warwick (2013, p. 101) make clear, *"a dialogic stance aims to foster learner agency, whereby students collaborate with others in seeking understanding, building from their own ideas and allowing other ideas and opinions to mediate and modify their thinking"*. We cannot expect students to improve their skills in collaboration and critical thinking without advancing the dialogic use of language in classrooms, and this is something that technology use can help to facilitate.

ENABLING TEACHERS TO MAKE STRONG CONNECTIONS BETWEEN THEIR PEDAGOGY AND THEIR INTENDED USE OF TECHNOLOGY IN THE CLASSROOM HAS A POWERFUL IMPACT ON THE WAY IN WHICH THESE TECHNOLOGIES ARE USED FOR STUDENTS' LEARNING.

Research has consistently demonstrated that computer support can facilitate students' sustained attention and engagement (Beauchamp and Hillier, 2014; Wegerif, 2007), and that external representations on large screens, for example interactive whiteboards (IWBs), are productive for grounding and sustaining attention, for visualisation of 'interthinking' and for prompting and directing participation in collaborative activities (Gillen et al., 2007; Hennessy and Warwick, 2010). Technology use can also support students in co-constructing knowledge and encouraging the dialogic critique of ideas through the creation and manipulation of digital artefacts (Hennessy, 2011).

Digital technology can be used as a powerful tool with the potential to support new forms of dialogue in the classroom. Research undertaken at the Faculty of Education at the University of Cambridge involving IWBs[6] suggests that enabling teachers to make strong connections between their pedagogy and their own — and students' — intended use of technologies has a powerful impact on the ways in which the technologies are actually used for learning in the classroom. Although powerful applications or pieces of hardware are necessary for specific jobs, opening up a space for dialogue and interaction through technology takes the use of technology beyond the provision of such tools. Overall findings from this project are broadly applicable to the use of most interactive technologies and are supported by the outcomes of another research project that considered student groups' uses of the IWB in science activities in primary schools (Warwick et al., 2010). Importantly, both projects enabled teachers to examine how (and what) they wanted to teach, and to design tasks that exploited the specific affordances of the technology — namely, the features perceived to facilitate particular pedagogic intentions — by directly aligning these with a dialogic approach (Mercer et al., 2010).

ONE CHALLENGE FOR PRODUCERS OF COMPUTING HARDWARE AND SOFTWARE IS TO ENVISAGE RELEVANT PROBLEM-SOLVING ACTIVITIES FOR MATERIALS THAT SET ACTIVITIES IN A MEANINGFUL CONTEXT FOR STUDENTS.

Additionally, the experience of Faculty staff working with Post Graduate Certificate of Education (PGCE) students on understanding and teaching computing suggests that one challenge for producers of hardware and software for computing activities is to envisage relevant problem-solving activities for their materials that will set activities in a meaningful context for students. The materials also need to be usable by teachers in the context of collaborative student interaction and dialogue. Importantly, a focus on curriculum subject learning alone (that is, without due consideration of how collaboration, problem solving and dialogue develop students as learners) is likely to lead to rather sterile uses of technology that may enhance the classroom experience to some extent but do not necessarily lead to a more productive use of classroom time for learning (OECD, 2015).

Some of the most interesting and arguably effective examples of educational technology use in school do not focus on using a single application, but use a broader range of hardware and software in conjunction with nondigital tools and resources. The following anecdotal cases, both set in the context of mathematics and involving students creating videos, provide good examples.

6 http://dialogueiwb.educ.cam.ac.uk/

Sharing learning about algorithms with video and QR codes [7]

One primary school identified a problem with aspects of mathematical knowledge. They encouraged their children to work on developing ways of explaining particular mathematical algorithms, and then to make videos of their solutions, which were posted on a secure Vimeo site. The students then created a QR code for their videos, and posted these around the school so that other students could access their solutions on their tablets.

Graphs and holiday making

A topic on understanding different graphs involved students accessing a video of a parent providing information to them as a 'customer' of their travel agency. They were charged with finding a range of holiday options that suited the adult's requirements for factors such as flight times, distance of holiday location and temperature range using a range of relevant graphs of different types. They had to present a video report, supported by relevant evidence online, to explain the holiday options for the adult.

The above vignettes illustrate how students collaborate with one another, share their understandings in relation to evidence, collectively evaluate and integrate information, reason about the best information to present and decide how to present it. Whilst none of the technology use that served these intentions was particularly revolutionary, it reveals pedagogic intentions of the teacher that go beyond subject learning, allied to an understanding of the ways in which particular affordances of the technologies can facilitate these intentions. In being given some agency to make decisions about technology use, students were able to bring to bear their combined expertise in addressing the problem, and in the second case to collaborate when away from school in seeking a solution. In sum, technology use can support students in creative activity and collective knowledge building by supporting dialogue that is productive for learning, in both peer collaboration and whole class contexts (cf. Hennessy, 2011).

SOME OF THE MOST INTERESTING AND ARGUABLY EFFECTIVE EXAMPLES OF EDUCATIONAL TECHNOLOGY USE IN SCHOOL DO NOT FOCUS ON USING A SINGLE APPLICATION, BUT USE A BROADER RANGE OF HARDWARE AND SOFTWARE IN CONJUNCTION WITH NONDIGITAL TOOLS AND RESOURCES.

7 QR code (abbreviated from Quick Response Code) is the trademark for a type of matrix barcode (or two-dimensional barcode) first designed for the automotive industry in Japan, see https://en.wikipedia.org/wiki/QR_code

4

Perspective 4

The central role of teacher education in the successful integration of digital technology into the classroom

One important contributing factor influencing teachers' adoption of technology is the quantity and quality of technology experiences included in their pre-service teacher education programmes. To prepare pre-service teachers for effective technology integration, teacher educators need to support student teachers in building knowledge of effective pedagogical practices, technical skills and content knowledge, in addition to developing their understanding of how these concepts relate to one another (Tondeur et al., 2012). Effective pre-service teacher education cannot simply focus on how to use technology, but must focus on how technology is used for teaching and learning.

TEACHER EDUCATION PROGRAMMES SHOULD NOT SIMPLY FOCUS ON HOW TO USE TECHNOLOGY, BUT SHOULD INSTEAD ADDRESS HOW TECHNOLOGY CAN BE USED FOR TEACHING AND LEARNING.

In many contexts (including the UK), teacher education programmes (including Post Graduate Certificate of Education courses) have full curricula, and student teachers already find participation in such programmes intensive. It is not surprising that such students end up having relatively limited exposure to appropriate technology use for the classroom, given the large volume of material covered, combined with a significant amount of practical teaching experience (all in a relatively short space of time). A reasonable mitigation strategy is to provide further opportunities to newly qualified teachers (as well as TPD for all teachers) to further develop their own approaches to teaching with technology.

While teachers are, in principle, able to use technology in the classroom to reshape learning activities to varying degrees (SAMR), a number of multi-faceted, teacher-level enablers need to be in place in order to successfully integrate ICT in schools (also see Perspective 2). Effective *in-service* TPD is one such enabler, and the importance of all teachers having regular TPD opportunities cannot be overstated. For example, in the context of investigating tablet use in schools *"findings suggest that a structured professional learning program may assist some teachers to move from the enhancement to the transformation stage"* (Geer et al., 2016, p. 8).

There is a growing consensus that teachers should drive their own TPD rather than being passive recipients (Wastiau et al., 2013). Holding regular discussions with teaching staff is one potential way to stimulate peer-learning exchanges between teachers and, in turn, promote 'on the job' TPD (ibid). Practitioner-led research (and related approaches) map well onto the key features of effective TPD, and the sharing of reflective professional practice is widely acknowledged as being beneficial (e.g. Twining et al., 2013). It has also been suggested that online learning communities, as well as other approaches closely integrated into teachers' daily practice, have the potential to support new patterns of TPD (Wastiau et al., 2013). However, such new patterns are most likely to be helpful to teachers who already have both a reasonable level of technology confidence and the facilities to make effective use of online learning (Laurillard, 2014). Significantly, this is usually not the case in developing country contexts.

WITHOUT APPROPRIATE TPD, GENUINE PEDAGOGICAL TRANSFORMATION FACILITATED BY TECHNOLOGY IS UNLIKELY TO OCCUR.

TPD can also serve to overcome problems such as a lack of teacher confidence (for example, teachers that are not comfortable using educational technologies due to a lack of relevant pedagogical expertise or practical experience), a lack of teacher competence (which is linked to other issues such as time and technical support) and teacher resistance to change (Bignimlas, 2009). Indeed, unless these and related issues (for instance, teachers applying technologies in a simplistic manner; Twining et al., 2013) are overcome, then genuine pedagogical transformation facilitated by technology is unlikely to occur.

Features of effective TPD

A unique set of challenges can be encountered when devising and delivering TPD to support the introduction of educational technology and it is critical to acknowledge these. Constructive use of technology can redefine academic disciplines (including their methodological tools), and it is therefore essential that specialist subject teachers understand how technology has changed the nature of their fields (Twining et al., 2013). Technology can support new approaches to supporting learning, which can align with contemporary understandings about how children learn, such as constructivist and sociocultural approaches. The pedagogical beliefs that teachers possess can also have an adverse effect on how teachers integrate technology (Voogt et al., 2013). There may be resistance to change due to teachers' ingrained beliefs, the fear of losing authority or difficulty in "letting go". TPD related to educational technology must also consider how to prepare teachers to integrate technology into their pedagogical practice, given the instability often associated with the rapid development of technology (ibid). The importance of TPD in dealing with these factors cannot be understated: problems can arise where ongoing support and TPD directly related to pedagogy are not available (Power et al., 2014).

It is essential that the complexity of teachers' knowledge is recognised when considering approaches to teachers' initial preparation and continuing professional development. Indeed, it is not sufficient to design TPD that treats the subject, pedagogy and technology separately, without regard to the intersections between these areas (Twining et al., 2013). Within the context of using educational technology, effective TPD (which can be seen as forming a continuum from pre-service to in-service and lifelong professional development) requires an integration of discipline expertise, pedagogical expertise and technology competence (ibid). The Technological Pedagogical Content Knowledge (TPACK) framework is one way of conceptualising different "domains of knowledge" required for effective teaching using technology. A systematic review of 55 studies in this area by Voogt et al. (2013) asserted that TPACK stems from the notion that technology integration in a specific educational context benefits from a careful alignment of knowledge about content, pedagogy and the potential of technology, and that teachers who want to integrate technology in their teaching practice need to be competent in all three domains. Arguably, the value of TPACK is that it is an *"intuitive and easy-to-communicate concept"* (*ibid.,* p. 10). However, *"from a theoretical perspective, TPACK is a very complex concept"* (*ibid.,* p. 11) that has led to diverse understandings, and is considered to lack a well-defined knowledge base or a way to assess a teacher's TPACK in practice.

TPD in the international setting

The World Economic Forum has identified how TPD (in addition to pre-service teacher education) should be the overriding priority for education policymakers at school, regional and national levels: TPD is the most productive means of supporting technology use to improve learning outcomes (as opposed to the current tendency to simply invest in technology that supposedly offers a shortcut to higher school standards: World Economic Forum, 2015). This is, in part, because TPD offers a means of transforming the practice of those teachers who are entrenched in using prescriptive or directive ways of instruction that are neither engaging nor effective (ibid). Moreover, school-based TPD programmes (for instance, in Kenya) have shown that TPD can be effective in helping teachers adopt learner-centered methods (UNESCO, 2014). Quantitative research evidence demonstrates that interventions involving TPD can have an impact on primary school student learning (McEwan, 2014), and the author comments that *"it is telling that almost all successful instructional interventions in our sample include at least a minimal attempt to develop teachers' capacity to deliver effective classroom instruction"* (*ibid.,* p. 27-28). Similarly Hattie's (2009) renowned meta-analysis shows an overall large effect size (0.62) for professional development. To support the implementation of educational technology effectively, it is essential that TPD clearly focuses on pedagogy and the curriculum, rather than the learning of generic ICT skills (Power et al., 2014). Furthermore, whether teachers are working at the pre- or in-service level, it is essential that school leaders and other stakeholders recognise that it can take time for teachers to become acquainted with technology resources. Programmes should not expect "quick wins" nor changes in practice to arise from brief "training" sessions (Power et al., 2014). Instead, models of effective TPD describe a sustained process (1-2 years) of reassessing pedagogy and reflecting upon practice (Cordingley et al., 2003; Hennessy and London, 2013). The research literature is unequivocal that one-off TPD events, such as a one-day (or even a five-day) TPD event, have little impact on teaching practice and classroom learning.

What do general insights into TPD tell us about the role of TPD in supporting ICT? The international development literature resonates strongly with insights from the the overall TPD literature. For instance, TPD helps to inform teachers' ability to develop, adapt and deliver appropriate curricula that promote learner progress (Nag et al., 2014). In addition, teachers' confidence to use educational technologies within their everyday practice can be enhanced through TPD (although this will, of course, require some sort of time and/or financial investment; Pitchford, 2015).

Recent research undertaken at the Faculty of Education (University of Cambridge) in the context of the OER4Schools programme in SSA (Hennessy et al., 2015B) corroborated insights from the wider research literature (see reviews by Westbrook et al., 2013; Orr et al., 2013; Hennessy et al., 2010), and suggests that effective TPD programmes:

- are long-term and structured;
- develop teacher agency and leadership;
- focus on classroom implementation;
- align with teachers' existing knowledge, practice and contexts;
- create opportunities for reflection, collaboration and teacher peer support (reflective communities of practice);
- attend to issues influencing teacher motivation to participate (policy, career development and certification);
- use digital technology as a motivator for professional learning and pedagogic change;
- encourage and support teachers in obtaining resources;
- recognise the interplay between teacher and head teacher professional development.

With regard to ICT, Hennessy et al. (2010) also suggest that programmes should be ***"pedagogically rather than technically focused and concerned with integrating ICT use into subject teaching rather than as a discrete subject in school; likewise technology needs to be infused into an entire teacher education programme, not a 'bolted-on' course"*** (p. 94). There has been broad awareness of this for over a decade (UNESCO, 2002; SITE, 2002). Similarly, an OECD report (2002) concludes that there is an international consensus that ICT is not an educational goal in itself ("learning about ICT"), but that ICT is a tool that can help to introduce pedagogical approaches that focus on active learning. However, this is still far from the reality in most teacher education colleges across sub-Saharan Africa today, and indeed school classrooms, where ICT is still taught as a discrete, separate topic.

Hennessy et al. (2010) also draw some important messages from the national in-service initiative a few years ago (for school teachers in England) around the use of ICT in teaching, which was widely regarded as a failure (with some pockets of success). They highlight ***"the inadequacy of centralised skills-focused approaches, especially those with online access to trainers"*** (p. 91; with reference to Davis et al., 2009), and comment that

> The most successful model proved to be an 'organic' approach that provided school-based training designed to support evolution of each teacher's classroom, school and region, as well as the training of the ICT teacher trainers. … For the majority of teachers, the training was located in their own school using the school's equipment and resources. In addition to face-to-face training, teachers used workbooks and worked in groups on assignments in their own classrooms. … There was a complementary community of practice for the ICT trainers. … The simple strategy of 'training the trainers' centrally so they may cascade workshops to others in their locality was not recommended (Hennessy et al., 2010, p. 91).

The role of the head teacher and the overall school setting is important, and rather than working with individual teachers, whole-school approaches such as Leadership for Learning (Frost, 2014; Swaffield et al., 2013) or the Index for Inclusion (Booth and Ainscow, 2011) should be considered. We also note that the above points apply equally in programmes with or without technology, and (apart from one) are not specific to technology. TPD for the effective use of technology does not have special rules, but needs to follow general TPD insights. There are of course some technology-specific insights as well. While motivational gains of technology use for children have been discussed in the research literature, the above research also suggests that the opportunity to learn to use new technologies can motivate teachers to engage in TPD (Hennessy et al., 2015B), particularly when these teachers do not have extensive access to technology otherwise (see also Carlson and Gadio, 2002).

Teachers learning with ICT

The previous section discussed TPD to support ICT integration in the classroom, with a view to effectively promoting students' learning in subjects other than ICT. Similarly, we may consider how ICT can be used to helpteachers learn about effective classroom teaching (rather than learning about ICT). In other words, the aim is not to develop teachers' technical ICT skills, or integrate ICT into the classroom, but to use ICT as a way to support teachers' own learning.

ICT use can enhance teachers' professional knowledge and capabilities, for instance by extending subject knowledge, supporting preparation for teaching and developing the range of teachers' existing pedagogical practices (Digital Education Enhancement Programme; Leach et al., 2004, 2005). Moreover, digital devices can be used to watch and critique video of classroom teaching, which has well-established benefits for teacher development (Haßler et al.,2014; Hennessy et al., 2015A, and references therein). However, as above, the reliance on ICT in itself is not helpful, and teacher learning may be elusive (Piper and Kwayumba, 2014). Teacher learning with ICT should follow the general messages drawn out above, seeking to enhance community-of-practice-based approaches.

5

Perspective 5
Mobile technology, international development and education

Before we move on to the role of mobile technology in international development, we first consider the overall setting of ICT in development and provide a brief overview of the notion of inclusive, quality Education for All, a global movement led by UNESCO.[8]

No digital dividends for developing countries

It seems counter-intuitive that the introduction of digital technology would not automatically pay off for developing countries, including in terms of educational outcomes. The World Economic Forum's Global Information Technology Report (2015) outlines how ICTs have become more powerful and widespread, while also acknowledging that they are pivotal in enhancing competitiveness, enabling development and bringing progress to all levels of society (WEF, 2015). In the developing world, the mobile revolution is starting to address the pervasive lack of telecommunications infrastructure. ICTs can also offer significant social benefits (*ibid.*). In many developing countries, various technologies (including radio, television, computers and mobile devices) are beginning to be used to supplement and improve children's learning. Similar to more developed education systems, these changes are accompanied by the growing expectation that technology will somehow 'revolutionise' learning processes and perhaps even the way education functions. However, while the digital revolution has brought immediate private benefits, Mishra (2016), cautions that *"despite great expectations — and frequent claims — of transformational impacts, the broader benefits of higher growth, more jobs, and better services have fallen short"*. To date, it is mostly higher income countries that are fully benefitting from this ICT revolution: advanced economies are better at leveraging ICTs than developing ones, and so the digital divide remains.

Inclusive, quality Education for All

The Dakar Framework for Action (2000) already recognised the preeminent role of teachers in providing basic education, stressing that to achieve Education For All, there is a need to enhance the status, morale and professionalism of teachers (Rose, 2015). In the current international discourse of equity and quality in international education (UNESCO, 2012; 2014; 2015; Moon et al., 2013; Lawrie et al., 2015), the focus is shifting from access to quality, with international priorities moving from children's access to schools towards quality learning outcomes as a result of an effective school-based education, facilitated by teachers. Social justice is a widely recognised perspective, and identifies three dimensions of a good quality

8 https://en.wikipedia.org/wiki/Education_For_All

education: **inclusion** (the opportunity for everyone to achieve), **relevance of learning outcomes** (within socio-economic settings and human development needs — including both indigenous knowledge and “world citizenship”) and **democracy/participation** (learner voice, governance, accountability; Tikly and Barrett, 2011).

The division of equity is no longer a North—South divide, but is now drawn along location, wealth, and gender lines (urban—rural, rich—poor and boys—girls). Initiatives that seek to have equitable impact on education need to explicitly address these disparities (“Education for All”, reframed by the new Sustainable Development Goals[9]). As the executive director of UNICEF Anthony Lake, identified, around 40% of public spending reaches the richest 10% of populations (UNICEF, 2015). This pattern needs to be reversed if the goals of Education for All are to be realised.

Within international development, education interventions in formal schooling are receiving particular attention, especially in the context of Universal Primary Education.[10] This means that there is a large and detailed body of evidence (not specifically related to ICT use) to explain what makes teaching practice and learning effective (Westbrook et al., 2013; Nag et al., 2014; Unterhalter et al., 2014). Because of the focus on Universal Primary Education, schools are often also the focus of ICT initiatives. Unfortunately, such projects often focus narrowly on the introduction of ICTs, without consideration of the broader research evidence, even where such evidence pertains directly to technology use (Wager et al., 2005; Hennessy et al., 2010; Power et al., 2014).

Overall, the issue of education financing is of paramount importance (Rose, 2014) if education targets are to be reached by 2013 (Rose, 2015). While the use of digital technology has associated learning gains, it is significantly more expensive compared with other interventions (metacognition, oral language interventions, collaborative learning; EEF, 2014) that also have higher learning gains. Often costs are not analysed, and the Mobiles for Reading (M4R) review (USAID, 2014, p. viii) comments that ***“little attention has been given to cost, mainly due to the donor-driven nature of M4R projects”***. Hosman (2010, p. 64) suggests that ***“a realistic assessment of the ways in which technology can complement and amplify current capabilities must be made before further scarce resources are invested in the ever increasing number of ICT-related projects implemented in the name of development.”*** From an equity perspective, clearly cost-effective interventions should be foregrounded. The OER4Schools model, which focuses on pedagogical improvements, but draws on technology where already available, offers a useful balance in this regard.

9 https://sustainabledevelopment.un.org/sdgs

10 https://en.wikipedia.org/wiki/Universal_Primary_Education

ICT as a resource-based intervention

Arguably, the shift from access to quality has been slow to penetrate some "ICT for education" projects in developing countries, and all too often, access is confused with learning, as in the statement *"mLearning is the ability to access educational resources, tools and materials at anytime from anywhere, using a mobile device" (GSMA, 2010, p. 6).* While ICT-focused projects sometimes show a degree of technology innovation, they often do not recognise wider educational concerns, including equity, sustainability and quality. While the distinction between access and quality learning resonates with the issues indicated in the other perspectives outlined in this paper, teachers in developing countries face additional challenges, which impedes the meaningful use of technology and exacerbates issues around equitable access (UNESCO, 2014).

MANY ICT-BASED INTERNATIONAL DEVELOPMENT EDUCATION PROJECTS HAVE A NARROW FOCUS ON HARDWARE AND SOFTWARE.

Many ICT-based education projects for schools have a narrow focus on (access to) hardware and software. However, education research shows very clearly that resource-based interventions on their own have very little impact, unless wider teacher professional development is undertaken. We provide three anecdotal examples to illustrate this.

The benefit of textbooks - for pupils or teachers?

The lack of school textbooks is a commonly cited obstacle. However, when textbooks were made available in the Rwandan Language Supportive Textbooks and Pedagogy project,[11] they were seen primarily as a resource for teachers, but not for students.

11 https://www.britishcouncil.rw/programmes/education/language-supportive-textbook-project-last

How ICT can support rote learning

When ICT is integrated into schools, projectors are often at the top of the wish list. Staff may argue that a projector saves the teacher time: he or she no longer needs to write on the board (from which the children normally copy), but children can copy directly from the projected image instead. This is perceived as ICT-based education, when in practice for the students, nothing has changed.

Reduction in class size is necessary but not sufficient

Large classes are also a pervasive problem. However, simply increasing numbers of teachers (without professional development) does not help: lecturing to 100 children is much the same as two teachers lecturing to 50 children each. It is also acknowledged that reducing class sizes (both in developing countries and the UK) has relatively little impact unless there is appropriate accompanying teacher education (McEwan, 2014).

What is clear is that access is not the same as learning, and that teachers need access to professional development opportunities if children's learning is to improve. Similarly, the Global Information Technology Report (World Economic Forum, 2015) cautions that where technology has been put to work in schools, education policymakers and technology advocates have tended to focus on the technology itself — to the exclusion of the educational reason for it. It asserts that what children urgently need are better teachers, not more gadgets in the classroom, particularly when funding and resources are limited.

Attempts to provide technology to students and teachers with otherwise few resources in impoverished schools is, of course, always met with enthusiasm. However, enthusiasm is often short lived, and for at least a decade now, it has been very clear that learning gains can remain elusive (Wagner et al., 2005; Hennessy et al., 2010; Power et al., 2014; Haßler et al., 2015). Where added value through technology is tested rigorously, sometimes the outcome is that there is no added value (Piper and Kwayumba, 2014; McEwan, 2014). It is clear that technology in itself does not add value to education, but that the crucial element lies elsewhere: while resource-based interventions have little impact, interventions that combine these with teacher professional development can have an impact on learning outcomes for children. The evidence points towards the notion that *"the role of teachers becomes more central — and not peripheral — as a result of the introduction of new technologies"* (World Bank, 2016, p. 147; Trucano, 2015; McEwan, 2014), and initiatives for schools thus need to include opportunities for teacher professional development (Perspective 4).

Effective use of mobile technology in the classroom

While the overall picture is still patchy, there is increasing evidence demonstrating how ICT can be successfully used in learning, motivating educators to change the ways that learning takes place and, crucially, what gets learned (Haßler et al., 2015). For instance, positive learning outcomes were observed in a tablet intervention supporting the development of early mathematical skills in primary school children in Malawi (Pitchford, 2015). Importantly, these learning outcomes were relative to the standard classroom practice of Malawian teachers, which itself is dominated by rote learning and thus limited in effectiveness. The learning gains demonstrate that the technology intervention was helpful, but only in relation to the status quo, rather than compared with more effective teachers. Indeed, the author remarks that rolling out the intervention *"will require investment in teacher training of both trainee teachers within teacher training institutions and existing teachers through continuing professional development courses"* (*ibid.*, p. 11-12).

The vignettes presented below (adapted from USAID, 2014) offer further examples of using mobile devices in education, and illustrate the associated complexity.

EDUCATION RESEARCH SHOWS THAT RESOURCE-BASED INTERVENTIONS ALONE HAVE LIMITED IMPACT: TECHNOLOGY IN ITSELF DOES NOT ADD VALUE TO EDUCATION.

Mobile devices for informal learning of literacy in developing countries

Observational studies indicate that if young learners in developing countries have a choice and the technical capability to do so, they often prefer to interact socially on a mobile phone rather than listen passively to an instructor or read a textbook (Tolani-Brown et al., 2009). Others have found that students' continuous interaction with web-based literacy activities is having a positive impact (for example, on reading skills; Leu et al., 2009).

The reciprocal nature of learning using mobile devices (such as the impact on metacognitive skills; Terras and Ramsey, 2012) and the ways that these have affected human discourse (Traxler, 2009) appears important: ICTs (such as mobile phones) are changing both what is learned and how learning takes place — and not just in regards to standard learning outcomes. In an era when people of all ages (including in resource-poor settings) are using mobile technology, there is little doubt that mobile devices have already become part of the informal spaces where learning takes place. This is, in part, because the ubiquity of mobile phones makes them attractive tools to use to support learning, as does the steady decline of prices for SMS messages, voice calls and Internet access.

It is increasingly evident that mobile devices offer young children in developing nations new opportunities and ways to learn, provided that they have adequate access to the technology. Mobile devices also offer other affordances, for example, the capability to use memory cards pre-loaded with content (such memory cards can also serve as inexpensive storage systems). Additionally, some features of mobiles can be customised depending on different users' needs (for example, adjusting text colour and size to overcome issues associated with poor eyesight) and the device's design and capability.

However, part of the conundrum of providing mobiles (or any other media device) for development is whether it will be put to 'good' or 'bad' use, and how to define 'good' or 'bad.' It is fair to say that the dramatically increased interest in ICTs and mobiles for learning has not yet fostered a sufficient scientific research base.

(Adapted from USAID, 2014.)

In light of the lack of sufficient research base on effective ICT use in education (Haßler et al., 2015; USAID, 2014), and rather than to hope that ***"so-called ICT skills, more often than not defined largely as the ability to use Microsoft Office packages, … will mystically enable [people] to become better citizens and to gain information that will be of some use to them and the societies in which they live"*** (Unwin 2005, p. 126), it would appear prudent to focus on what we know.

With regard to formal learning in schools, there is strong evidence that learning gains are made from metacognition, dialogue and collaborative learning (EEF, 2014; c.f. discussion above), and that effective use of such strategies needs to be supported by TPD. Attention to pedagogy, teacher support and development, as well as providing relevant curricular materials in school settings, are factors that contribute to the effective use of technology for learning (World Bank, 2016; based on Arias Ortiz and Cristia, 2014). Moreover, the shared use of devices (*ibid.*), particularly from an equity perspective, appears to be a key factor for effective use. The evidence points towards shared use being more effective (Haßler et al., 2015); shared use (in collaboration and over time) is clearly more equitable too. For instance, despite extensive engagement, approximately only one in three schools (Grades 4–6) today has access to the 'One Laptop per Child' (OLPC) initiative in Rwanda (Adam, 2015). If shared device use was envisaged, all children in primary (at all grades) could have access to the technology. Of course, equitable and effective learning aside, the reality may be that any actual use of devices by children remains limited despite theoretically having access (Adam, 2015; Girgis, 2015).

CHILDREN, PARTICULARLY DISADVANTAGED CHILDREN, URGENTLY NEED BETTER TEACHERS. GIVEN LIMITED FUNDING AND THE NEED FOR EQUITABLE ACCESS, RESOURCES NEED TO BE FOCUSED ON WHAT WORKS — INTERACTIVE TEACHING PRACTICES AND TPD.

6

Perspective 6
The role of educational content

The Global Information Technology Report (World Economic Forum, 2015) draws attention to content as a crucial challenge that must be addressed if we are to maximise the potential of ICTs in education. Digital educational content needs to be of high quality, must be culturally appropriate (for example using dominant languages) and must be targeted at educators. Content must be respectful of the particular population characteristics, and undoubtedly more can be done to tailor the design of digital resources for particular target groups (including girls and women; USAID, 2014).

CONTENT NEEDS TO BE APPROPRIATE FOR STUDENTS AND STUDENT LEARNING — IN TERMS OF CULTURE, CURRICULUM AND PEDAGOGY.

Learning outcomes for students

Teachers are most likely to use content that is aligned with what they need to teach (the curriculum). When using digital educational content, a curriculum map needs to be provided, which enables teachers to quickly access the content they need for a particular lesson. However, teachers are also most likely to use content that aligns with how they want to teach. As discussed above, there are certain strategies with strong evidence for student learning, such as metacognition, collaborative learning and dialogue (c.f. EEF Toolkit). When evaluating content for education, we may ask whether the content is aligned with such effective classroom practices. In other words, is the content usable in — or even designed for — the context of collaborative learning? Do the use cases envisaged for the content promote students' dialogic skills?

Importantly, this must be contrasted with the prevailing assumption that technology is for students' individual use, perhaps supervised by teachers. Therefore, initiatives seeking to procure 'educational content' delivered on digital devices (for the classroom), often provide individual e-learning content. While this may be appropriate for some settings (such as higher education), it certainly is not the setting envisaged by many effective learning strategies in primary or secondary schools. This fact — the use of individual e-learning content as part of teacher-facilitated classroom-based activities — does seem to be a hidden inconsistency, even in some very large-scale projects, such as OLPC Rwanda (Adam, 2015; Fajebe et al., 2013; elsewhere: Severin et al., 2009; Crista et al., 2012). However, the research evidence indicates that one of the main potential strengths of technology is in supporting students' own collaborative and enquiry-based learning. Insights such as these can be used to inform productive opportunities for technology-enabled quality teaching and learning in the classroom.

Supporting teachers

As remarked in the previous perspectives, for teachers to be able to use content as easily as possible, such content needs to be aligned with what is taught (curriculum) and how it is taught (practice). Ideally, this alignment is made explicit. For instance, the content that is provided should include at least some detailed and credible classroom scenarios (drawing on culturally appropriate, curriculum-linked resources), rather than leaving teachers to generate such alignment with curriculum and practice entirely by themselves.

CONTENT NEEDS TO SUPPORT AND SCAFFOLD TEACHERS.

This is particularly important where projects aspire to support teachers in their development towards more interactive practices. It is insufficient to simply provide some scenarios for how student-level content can be used, especially where teachers may not have a strong initial teacher education (as is often the case in developing countries). To maximise the use of technology tools, teachers in both formal and non-formal settings need to be taught to use these resources innovatively and effectively, while making sure that the technology is accessible to all (UNESCO, 2014). Bearing in mind that teachers need to be supported through regular TPD (Perspective 4), content at the teacher level needs to directly support structured TPD programmes. In other words, where teachers need a great deal of support, content cannot just be handed to teachers in bulk, but a strong TPD programme needs to be designed and then supported by teacher-level content.

The OER4Schools multimedia teacher development programme (www.oer4schools.org) is an example of such an extended programme, intended for teachers in low-resourced primary schools and teacher colleges (combined with teaching practice). It consists of 28 two-hour workshop plans, with sufficient detail for teachers to be able to peer-facilitate sessions. Each workshop plan features interactive activities that teachers can do (first in the workshop and then in the classroom), unique, professionally filmed video exemplars of interactive practices in Zambian and South African classrooms (with and without technology), as well as images, templates and accompanying texts. The programme is not prescriptive, but carefully supports teachers in devising and introducing interactive activities in the classroom that are aligned with the curriculum. Each workshop plan features extensive guidance notes for the facilitator. The materials were developed over several years in conjunction with local stakeholders and carefully adapted to the local context.

This approach is corroborated by the research literature (Westbrook et al., 2013; Orr et al., 2013), but to be contrasted with short workshops that often seek to introduce teachers to new hardware, software and content, as well as new pedagogical practices, in the space of a few days. A particular example of this is the so-called cascade model that uses a chain of "training" from "master trainers" to "trainers" to teachers. Each "training" is typically an intensive 5–10 day event that happens only once or perhaps twice per year, with subsequent implementation (classroom teaching) at the discretion of the teachers. Because the training is short, with a full curriculum, rote learning is often considered necessary — a view that mirrors teachers response to overfull curricula at school level. While some teachers may be inspired, and in favourable conditions some might implement some of the strategies introduced, the classroom realities of the majority of teachers are usually not addressed. The theory of change, namely that through short-term interventions, knowledge is transferred down the cascade without dilution, does not hold in practice; instead, the expertise tends to remain concentrated at the top of the cascade (Hayes, 2000).

With regard to content, a useful model in countering dilution is what could be called an "upward cascade" (Haßler et al., 2015B), where learning resources are positioned at the teacher level, not at the top of the cascade. Teachers spend most of their time teaching in schools. Thus, schools are probably the optimal central location for teacher professional development. Consequently, any content produced for teacher development should be geared towards school-based TPD (and associated classroom practice). Similar to OER4Schools, such materials should be relatively self-contained and should explicitly detail the programme's structure and expectations. In other words, if there was no cascade training, how much scaffolding is explicitly provided in the materials to enable groups of teacher to implement the programme autonomously?

OER4SCHOOLS IS A MULTIMEDIA TEACHER DEVELOPMENT PROGRAMME, INTENDED FOR TEACHERS IN LOW-RESOURCED PRIMARY SCHOOLS AND TEACHER COLLEGES IN SUB-SAHARAN AFRICA.

Sustainable investment in (open) educational content

Between 2008 and 2011, donors spent US$189 million per year on teacher education programmes (globally), equivalent to 2% of the education aid budget (GMR 2014, p. 25). By comparison, in 2004–2005, the United States federal government spent about US$1.5 billion on professional development for teachers in the USA alone (Birman et al., 2007, cited in Desimone, 2009). While this highlights the need to invest more in teacher education (and in education overall), we may also ask how much of this spending resulted in reusable outcomes, including policy briefs, research publications, as well as open content usable in other settings. Arguably, too many programmes' outputs remain confined within the executing organisations and ministries. Given the scarcity of funding, and the need for quality Education for All — clearly articulated in Sustainable Development Goal 4 — this is regrettable.

OPEN EDUCATIONAL RESOURCES OFFER A CREDIBLE MECHANISM FOR SUSTAINABILITY AND SCALABILITY OF EDUCATIONAL CONTENT.

Open Educational Resources (OER) offer a credible mechanism for sustainability and scalability of educational content. "Open" usually refers to legal freedom (Creative Commons licensing), but other aspects can be drawn out (c.f. three OER freedoms; Haßler and Mays, 2015), such as the ability to easily download content, without accessibility issues or excessive bandwidth requirements (Haßler and Jackson, 2010). The notion of open here is closely related to open-source software, where the openness helps distribution. OER offer more equitable aid investment: by releasing content as OER, it becomes available beyond the immediate beneficiaries.

In some education sectors, the manifest advantages of OER are recognised. For instance, research on college textbooks in the USA indicates that using open resources is more cost-effective than traditional approaches to textbooks (Hilton et al., 2014; Robinson, et al., 2014), and a significant programme to develop open K–12 textbooks is underway.[12] The initiative is funded by the US government and motivated by the research insight that the funding of open content (with digital use or on-demand printing) is more cost-effective, and therefore more scalable and sustainable. Given the existence of these textbooks, as well as other open resources (Haßler et al., 2014), there is arguably little point investing in developing proprietary textbooks. Instead, content creators should build on openly available texts, and tailor those to specific contexts.

While other government agencies increasingly recognise the importance of open licensing,[13] the number of openly licensed teacher development programmes (in developing countries) is still very limited (OER4Schools, T-TEL,[14] TESS-Africa and TESS-India[15]). The "Mobiles 4 Reading" review (USAID, 2014) concludes that only 16% of the projects reviewed were explicitly 'open source' in their approach, and notes that this contrasts with the common discourse about (seemingly strong public support for) open resources in the broader area of ICT for development. Sometimes, the need for cultural adaptation is cited as an impediment to the value of open resources. However, teachers' tolerance of minor cultural variation is quite high in some contexts, and teachers are often open to other cultural influences (Haßler et al., 2016). Similarly, participants in the UNESCO Access2OER discussion (Haßler, 2009) expressed a preference for having access to raw materials to make their own judgements, rather than decisions about availability of materials (and open licensing) being decided by an external agent. As insights from OER Africa[16] confirm, collaborative authoring and adaptation of OER works well, and represent an empowering, scalable and sustainable practice.

12 http://k12oercollaborative.org/
13 https://www.gov.uk/government/publications/dfid-research-open-and-enhanced-access-policy
14 http://www.t-tel.org
15 http://www.tessafrica.net and http://www.tess-india.edu.in
16 http://www.oerafrica.org

Conclusions

Throughout this report we have advocated a holistic iterative approach to technology-enabled effective learning. Technology must be fit for purpose and support effective approaches to learning undertaken by teachers and pupils. Teachers' inquiry should be guided by pedagogical insights and an overall sound theory of change. We frame the outcomes of this report in the form of a toolkit for discussion, which is meant as scaffolding for productive dialogue about technology integration in education between a broad range of stakeholders.

Toolkit for discussion

Technology, Resources and Learning: Productive Classroom Practices and Effective Teacher Professional Development

1. Exactly how will the technology use contribute to improved learning outcomes?

- Is the technology provided to teachers simply as a resource without details of classroom use?
- Is the (explicit or implicit) assumption that technology itself will transform learning ('technological determinism')?
- Is there a credible theory of change, rooted in experience and education research outcomes, that suggests precisely how technology-related activities lead to better learning outcomes?

2. Is the proposed technology use (hardware, software and content) aligned with (a) the curriculum (including content, skills and overall goals) and (b) effective classroom practice?

- Does the technology use promote students' dialogic skills, collaborative learning and metacognition?
- Is the scenario one of individual e-learning (supervised by teachers) or is shared use envisaged (in conjunction with teaching practices such as dialogue and collaborative learning)?
- Are the classroom scenarios detailed and credible (with appropriate, curriculum-linked resources)?
- Is the assumption that teachers will create this alignment between the curriculum and practice themselves (without guidance); if not, how much guidance is provided?

3. Is the technology provided through a one-off intervention (without trialling)?

- Or, does the intervention envisage iterative cycles of engagement with teachers, children and other stakeholders?

4. How will change over time be measured?

- Where within SAMR is the intervention positioned?
- How realistic is this positioning? To what extent is the positioning supported by the overall theory of change (based on research outcomes)?
- What are the baseline levels of participating teachers' knowledge, skill and attitudes — and of student knowledge?
- How will learning gains be measured and is there any comparison group? Can observed change be attributed to the intervention?

5. What provision is made for effective teacher professional development (TPD)?

- Does the initiative focus primarily on resources for the classroom (such as infrastructure, physical resources, books, computers, more classrooms, more teachers), or is provision for TPD also made?
- What is the nature of the TPD?
- Is there a credible approach to professional development (long-term; focussing on ICT-enabled subject pedagogy), or a simplistic ICT training for teachers (short, one-off workshops)?
- How will enough time be made available for teachers to participate in a sustained way?
- How motivated are they to do so?
- Is there provision for certification?

6. Is the particular technology suitable for the purpose and the context?

- For instance, is battery life adequate for deployment in rural areas with little power or connectivity, or have solar powered options been considered?
- What assumptions are made about Internet connectivity?
- Is the number of devices appropriate for the class size? Is shared use envisaged (in order to reach more students and classes)? Where technology resources are limited, has a rota been drawn up?
- What is the setting in which the content is used (that is, formal vs. informal education or both)?

7. Does the technology use focus on equitable access to learning, or does it focus on "easy-to-reach first"?

- How will the technology reach and support teachers and pupils in deep rural areas (without access to power, mobile internet or even mobile signal)?
- How will the technology reach and support female teachers and female pupils?
- Is provision made for the inclusion of all teachers and pupils, including those who have special learning needs?
- How are the devices used (device–pupil ratio; 1:1 or shared use)?

8. How scalable and sustainable is the intervention?

- Is all educational content published as Open Education Resources?
- Is the software open source or are (paid or free) licences required?
- Is all content and software easily downloadable? Or is access impeded by high bandwidth requirements, poor formatting and registration?
- Are reports published regularly, offering rigorous insights and critical reflection?

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