Girls' Education Challenge

UKaid from the British people

Thematic Review

Educational Technology

March 2018

GEC Thematic Reviews

This paper is one of a series of thematic reviews produced by the Fund Manager of the Girls' Education Challenge, an alliance led by PwC, working with organisations including FHI 360, Nathan Associates and Social Development Direct.

The full series of papers is listed below:

- Understanding and Addressing Educational Marginalisation
  Part 1: A new conceptual framework for educational marginalisation
- Understanding and Addressing Educational Marginalisation
  Part 2: Educational marginalisation in the GEC
- Economic Empowerment Interventions
- Community based Awareness, Attitudes and Behaviour
- Addressing School Violence
- Girls' Self-Esteem
- Extra and Co-Curricular Interventions
- Educational Technology
- Teaching, Learning and Assessment
- School Governance

For further information, contact the Fund Manager at
girlseducationchallenge@uk.pwc.com

Table of contents

Executive summary

The use of technology to support educational outcomes (ed-tech) is an important feature of the Girls' Education Challenge (GEC), and an area of innovation within the portfolio. Of the 37 projects in the first phase of the GEC, four were specifically designed around ed-tech delivery models and a number of other projects used technology, to varying degrees, as part of their broader interventions. This paper sets out some of the learning associated with this work.

The paper is framed around three main objectives for the use of ed-tech in GEC projects: to improve teaching and learning; to support more effective school management (in particular the use of data) and to support awareness raising and attitudinal change regarding girls' education.

Key findings from this review include:

1. Technology can improve data reliability and depth
2. Technology can have a motivational effect on students and teachers
3. Media/technology has significant potential reach and impact, although it is hard to measure
4. ICT has the potential to help children with disabilities
5. Creative and context specific approaches are required to overcome barriers to reaching marginalised communities through technology.

Based on the existing literature and experience, we know that the use of technology in schools needs to be part of a broader approach to improving teaching and learning processes and content. Drawing on the GEC endline evaluations and other sources allows us to identify some key lessons on the use of ed-tech to improve attendance and learning.

1. There are a range of additional barriers to the implementation of ed-tech interventions; however these can be overcome, for example through new partnerships or community support.
2. Data needs to be well-integrated and stakeholders need to be engaged to support the collection and use of reliable data
3. Students need access to the hardware and ed-tech content, supported by sufficient time spent on task. This could be achieved through stronger classroom management, which should also monitor gender differences in access to technology.
4. It is important to support teachers to use technology *and* use technology to support teachers. It is important that in-depth, well planned training is provided for teachers in order to use technology effectively, supplemented by on-going, in-school support. Technology such as online resources can also support teachers to improve their practice.
5. Learning content needs to consider the language needs of students.

The GEC provided a useful testing ground for a range of ed-tech interventions. A central theme of this report is that ed-tech can be integrated into a range of interventions, whether in classroom learning, school management or broader strategies around girls' education. However, consideration must be given to the potential barriers to the implementation of ed-tech interventions.

1. Introduction

This paper provides an overview of the role played by technology (ed-tech) in Girls' Education Challenge (GEC) projects and the key lessons learned from this work. This covers the use of Information and Communications Technologies (ICTs) for a range of educational purposes: teaching and learning, school management, and broader awareness and communications. Ed-tech was not a core focus of GEC projects, but has been an important area of innovation within the programme.

This paper outlines the existing evidence base for using technology in education and then describes the various ways in which technology has been used under GEC, including the intended benefits at design stage represented through project theories of change. The main aim of the paper is to capture lessons from delivery and from project endline evaluations. The lessons are drawn mainly, though not exclusively, from the four projects that were designed around a core technology intervention. Some of the GEC projects mentioned in this paper will continue into the GEC's second phase, and should build on current achievements and address the challenges earlier interventions have faced. The lessons set out here can also contribute to DFID's broader learning regarding the effective design and implementation of ed-tech interventions.

Based on broad experience, the emerging evidence and DFID's internal guidance, the starting premise for this work was that technology can be a tool for improving learning and other educational outcomes, but that it needs to be integrated with a broader approach that is firmly based on good teaching practice and school management.

2. Overview of the educational technology discourse

There is a growing interest in the use of technology to drive educational improvement in low-resource environments. Early ed-tech interventions were often characterised by a naïve optimism (in both developed and developing countries) that simply providing the access to software and hardware would enhance learning outcomes. Many of these initiatives failed to live up to initial expectations (Severin et al 2011, Cristia et al 2012). It is now widely recognised that simply using technology does not bring about a positive impact on education (OECD 2015), but that it is most effective when integrated within holistic education programmes rather than viewed as an isolated driver of change.

Ed-tech research and evidence

A mapping tool created by DFID collates and summarises much of the current ed-tech literature (Muyoya, Brugha, and Hollow 2016). It shows that most existing studies are observational and focused on qualitative accounts of impact, with few experimental studies being included in the tool. Over half of the studies cited self-report a positive effect from using

technology in education and less than 10% report a negative effect[1]. The most frequently occurring interventions relate to curriculum and pedagogy, teacher training, teacher or student ICT literacy and use. The most frequent outcomes related to teaching quality and student achievement.

The assessment of the PRIMR programme in Kenya is an example of a rigorously evidenced study. It evaluated the impact of technology in supporting a reading programme in primary schools. The programme included tablets for TAC tutors (who trained and supervised teachers), tablets with resources for teachers, and e-readers for students. All three interventions had a measurable effect on learning, though the interventions that focused on teachers and trainers proved most effective and most cost effective (Piper and Kwayumba 2014, Piper and Mugenda 2014).The evaluation points to the importance of good quality and relevant learning materials, and targeting specific areas of learning.

Another example of best practice is the DFID funded English in Action programme in Bangladesh, which used mobile-based content ('Trainer in the Pocket') as part of a school based professional development programme. Research demonstrated a positive impact on student and teacher ability in English (EIA 2014, Walsh et al 2014). Both of these studies emphasise the vital role of engaged, equipped and motivated teachers. There are also various synthesis studies that group the evidence within particular focus areas of education technology, including mobile learning (UNESCO 2014), mobile phones in learning (Porter 2016), and technology in education in emergencies (GIZ 2016, Gladwell et al 2016).

Some key points regarding the wider literature of ed-tech include:

- Despite the large number of ed-tech programmes, there remains a lack of detailed and robust evidence that can be used to reliably inform future practice. The evidence is stronger from OECD rather than from low income countries (Trucano, 2016). Although some evidence exists, studies rarely assessed the specific impact of technology on learning outcomes.

- There is a growing recognition of the importance of assistive technology, including of ICT, for children with disabilities (UNICEF 2013, DFID 2010). A growing evidence base demonstrates that appropriate assistive technology can enhance the educational engagement of children with disabilities; helping them communicate more effectively, see and hear better and participate in learning activities (WHO 2015). Accessible ICT provides an opportunity to ensure out-of-school children with disabilities can also access a quality education. However, it is critical that the accessibility of ICT equipment is considered in advance because retrofitting existing digital materials is difficult (see Center on Online Learning and Students with Disabilities[2]).

1 Worth noting that the DFID map does not assess the quality of evidence presented in the research.
2 This can be accessed online here: http://www.centerononlinelearning.res.ku.edu/center-reports

Frameworks and good practice guides

There are multiple guides that draw together summaries of good practice in education technology (GBC 2014) and provide guidance regarding overall policy and delivery principles. The World Bank SABER-ICT policy framework (Trucano 2016) identifies overarching themes that those involved in forming and implementing ed-tech policies and programmes should be cognisant of: vision and planning; ICT infrastructure; teachers; skills and competencies; learning resources; management information systems; monitoring and evaluation, assessment, research and innovation; and equity, inclusion and safety. The World Bank (Trucano and Dykes 2016) work also emphasises the importance of leadership, integration with a holistic vision of education, and the need to focus on supporting and meeting the needs of teachers.

A 2011 USAID compendium of principles for effective programming (USAID 2011) reported that despite the rapid evolution of technology and changes in costs and access, the underlying principles remain relevant and highlight the need for a strong focus on educational outcomes, and the ways in which total costs of ownership (TCO) can be considered when ed tech is being used. MIT also provide a framework for assessing the appropriateness of education technology use (MIT, no date).

Building on good practice

Despite the absence of comprehensive evidence, it is possible to summarise the discourse regarding good practice in education technology in low resource environments within the following framework.

Figure 1, Key Design Features Framework:

Design features	Good practice
Context appropriate	• Recognise that what works in one place will not necessarily work elsewhere; response based on demand from intended users (Walsh 2014, Unwin 2009). • Integrate with the broader education system and align with the national curriculum (Trucano 2015). • Be realistic regarding the pace of change that is likely to take place.
Focused on educational outcomes	• Focus less on the provision of hardware, and more on content and infrastructure, including the development or use of digital content which is locally appropriate. • Focus on empowering and equipping teachers in a way that actually works for them and provides long-term, in-school support (Severin et al 2011).
Develops systems and capacity	• Build the understanding, active buy-in and motivation of school leaders (IICD 2015).

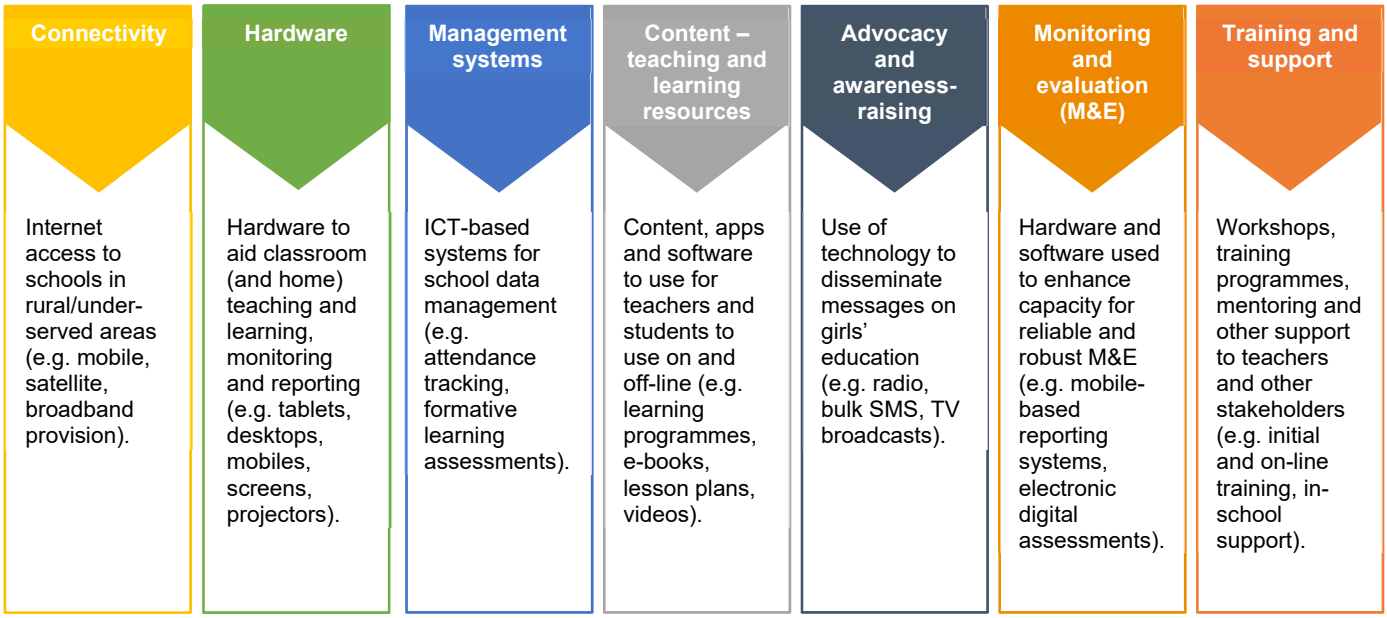
	• Mobilise a range of partners, including governments and the private sector. • Develop a robust and realistic sustainability plan from the outset (Severin 2011). • Focus on lesson learning throughout implementation rather than just at the programme end (Unwin 2009).

3. Educational technology in the GEC

3.1 Overview of ed-tech inputs in the GEC

During the first phase of the GEC, 20 projects made use of technology, ranging from significant investments in ICT for classroom teaching as the main project intervention, to smaller scale use of technology within other interventions. These included providing tablets for teacher training, computers for classes for out-of-school girls, or software to track student attendance.

Figure 2, Technology inputs in GEC projects:



A table of the projects that used technology in the GEC portfolio is included in Annex 1. Of note are three of the projects from the Strategic Partnerships (SP) Window, co-financed with private sector partners, and a fourth from the Innovation Window:

- iMlango (Kenya): led by Avanti Communications, provided connectivity and computer labs to rural primary schools in three counties in Kenya. Learning content was managed through a portal, including Maths Whizz (a personalised tutoring system) and a range of literacy and other resources. Teachers also provided equipment and training for whole class teaching, and schools all have a sQuid card attendance tracking system.

- Discovery Girls (Kenya, Ghana, Nigeria): a Discovery Learning Alliance managed project in three countries, provided a mix of interventions to around 1500 schools (mainly primary). Each school was equipped with a Learning Centre, with TV, video and a DVD resource library, and a wide range of materials mapped to the curriculum. Teachers were trained to use the resources and to adopt more gender responsive pedagogy.

- Connect to Learn (Myanmar): An Ericsson managed consortium provided connectivity to rural secondary schools, with content managed through a portal, focusing on English language, maths, life skills and a range of other topics with teachers trained to use the resources in class.

- MGCubed (Ghana): Varkey Foundation Innovation Window project, provided maths and literacy classes through online technology platforms to remote/rural schools. Classes were delivered by master teachers based in Accra and broadcast directly to 72 remote/rural primary schools simultaneously, with teachers facilitating learning in lessons.

Each of these interventions was designed around a core technology component, aiming to enhance classroom learning through provision of previously unavailable content. Other GEC projects used technology to a lesser degree as part of other interventions. For example, Camfed International (Zimbabwe and Tanzania) included mobile technology to support mentors; the Wasichana Wote Wasome (Let Girls Learn) project in Kenya, supported teachers with tablet-based teaching resources; and the Jiemelishe (Kenya) project, used biosim technology to track attendance linked to a range of other demand side activities.

Indicators used in project logframes to track progress in delivery or use of technology outputs are set out in Annex 2. Some projects have identified limitations in how their logframes tracked the use of technology (e.g. CRANE, Jiemelishe).

3.2 Theories of change: expected benefits from ed-tech for girls

Project theories of change, either explicitly set out at design stage, or developed through implementation, are structured around the use of technology to meet three objectives. Each could be characterised as an intermediate outcome on the path towards the common outcomes for all phase one GEC projects: learning, attendance and leverage/sustainability.

1. Supporting teaching and learning: A range of approaches focused on improving teacher capacity and access to teaching and learning materials. Key interventions included providing a mix of high quality cloud or video-based content, capacity training and support for teachers to use technology in teaching, and provision of hardware and connectivity where it was not in place. A common assumption was that these solutions would increase both teacher and student motivation and interest in learning. In some cases, it was assumed that connectivity would enable provision of a wider range of up-to-date learning content. Another important feature was the potential to make learning more interactive and adapted to learner needs and existing skills.

2. Improved school management, data collection and reporting: Some models focused on better school management and use of data, whilst others provided a platform for engagement with girls and other stakeholders. The aim of these was to improve life skills and

girls' awareness about their rights to education, and to better monitor girls' attendance and learning. These approaches rested on an assumption that reliable and up-to-date data on students would help schools to identify where individual students were struggling (e.g. at risk of drop out, or falling behind in foundational skills) and follow up as needed. Theories of change anticipated that such systems would improve attendance, particularly when combined with other support to marginalised girls.

3. Promote awareness around girls' education: Projects assumed that increasing awareness among families and the community of the challenges faced by girls would have a direct or indirect effect on their educational outcomes. Projects used SMS, radio, TV and other media to broaden reach and help expose girls and communities to new role models and ideas, to show how education can transform girls' lives.

Across each of these objectives a fundamental challenge has been that the most marginalised girls may be in schools and communities that lack the necessary infrastructure and resources to roll out such ed-tech interventions. Unless well targeted, interventions could exacerbate emerging digital divides or broaden inequality in the provision of quality teaching and learning. Projects have generally aimed to address this by providing connectivity through satellite technology, upgrading of infrastructure to the extent possible (e.g. getting schools on grid or providing solar panels and upgrading school security), or in some cases providing less high-tech, off-line solutions, focused on teachers. Notably, the use of technology to support the specific needs of children with disabilities was limited, and this is an area where more focus could be given in the next phase of GEC.

4. Key findings

For those GEC projects delivering technology-based interventions, there have been mixed results in terms of measured outcomes, and in some cases inconclusive results. The evaluations can tell us whether a project achieved its outcomes, however, we cannot isolate the contributions of specific interventions. This limits the extent to which GEC can contribute evidence at this stage showing the direct contribution of technology to learning results, although the next phase of GEC may be able to offer more robust evidence of this kind. However, some findings have emerged from the first phase of the GEC, and are explored below.

Technology can improve data reliability and depth

Several projects used technology to help schools collect and use data on student attendance and learning. There is significant interest in mechanisms to improve national data reliability; although GEC experience is at a school and project level, projects could provide lessons for ministries on what is possible. A range of different approaches were used in order to enhance school management and track student and teacher indicators at the programme level. These included, among others, the sQuid card system used by iMlango (Kenya), the biometric iris recognition used by Jiemelishe (Kenya), and the SchoolTool software used by Promoting Equality in African Schools (PEAS). It is not possible from evaluations to draw firm conclusions

in terms of results; however, some qualitative and anecdotal evidence from projects indicates that digital systems for tracking attendance have encouraged student attendance more than traditional class registers.

Most GEC projects had challenges in collecting reliable attendance data. Technology does not necessarily provide a solution where there are incentives to falsify data (e.g. where linked to per capita school funding), but there is some evidence that it can help improve reliability. The Jielimishe Kenya project introduced biosim attendance tracking system using an iris recognition system linked to a smart phone to record each student's presence in the morning and afternoon sessions of school. The biosim attendance tracker recorded significantly lower levels of attendance than were recorded by the programme evaluators (using class registers and spot-checks.) This discrepancy requires further analysis, but it seems that an online system may provide more accurate data than other methods. The availability of data supports detailed analysis: projects were able to tell how girls' attendance varied day by day, by week or by season, which can help school or system level planning.

The introduction of management tools also provided programmes with increased ability to understand the reasons behind changes that were observed in schools. For example, use of the SchoolTool meant that PEAS were able to explore why teacher absenteeism reduced from baseline to midline and then remained constant from midline to endline. Their school information management system enabled tracking of the reasons for student and teacher absenteeism and enabled school leaders to improve teacher accountability regarding their attendance. When the project investigated teacher absenteeism, they found occurrences were mostly authorised and were below the norm in Ugandan schools. Camfed's project in Tanzania and Zimbabwe trained their mentors as well as local officials to collect and report data via mobile phones, linked into an online database. This enabled collection and use of reliable individual level data for all of the girls receiving support.

Technology can have a motivational effect on students and teachers

Introducing technology to classroom teaching can be motivational for teachers and students. Projects reported excitement among students and teachers about using modern technology for learning. For example, at endline, 67.8% of girls surveyed in iMlango reported that using computers had made school more exciting, and to some extent the evidence suggests this is changing the way they think about their own future. Given the high degree of interest and enthusiasm for learning generated by their use of computers in classes for out-of-school girls the CRANE project set up an IT Bus service with the aim of extending the reach of this intervention.

Across the portfolio, there is a narrative from endline reports of technology generating interest and motivation, among teachers as well as students. This may be through a novelty factor (especially in rural areas where there is limited exposure to new technology), a sense that this is a modern approach to teaching, or through provision of new and relevant content. The Discovery evaluation notes that the presence of a television is a significant pull factor for school enrolment and attendance, with about 50% of head teachers interviewed mentioning that video-based learning attracted more students to their schools. However, there is no

evidence that this led to increased learning outcomes and given the timeframe of these interventions, it is hard to know if this effect is sustained.

ICT has potential to help children with disabilities, but is under-utilised across the GEC

Cheshire Services Uganda implemented a project specifically focused on children with disabilities. The project worked mainly in mainstream schools, although some of these schools catered specifically for children with disabilities. After midline, and with additional funding from the GEC, the project invested in Resource Centres in 20 schools including equipment consisting of computers, projectors, TV and DVD players, and internet connections. While the Resource Centres were not implemented long enough for any meaningful results to be collected in time for the endline report, anecdotal evidence suggests that the ICT equipment engaged all children (those with disabilities and those without), with projectors being particularly useful.

In iMlango schools there have been reports of children with disabilities using the computer lab with good results in terms of student motivation. There have also been some reports of individual children with disabilities making significant gains in learning, although the type or severity of the children's' disabilities is unknown. This evidence is anecdotal and there is a recognition that the projects online content needs to change to be accessible to children with disabilities.

Creative and context specific approaches are required to overcome barriers to reaching marginalised communities through technology

Endline evaluations revealed there is a challenge where technology is used to raise awareness around girls' education, if the intended audience has limited access to the messaging platform. This may be due to physical access to devices, language and literacy barriers, or social norms around ownership and use. For example, in Northern Nigeria, the Discovery project cited low TV access among households. In addition, the shows were initially only broadcast in English in a region where the language is not widely spoken. Shows were later aired in Hausa and this increased the reach among the target population. For Steps Towards Afghan Girls Education Success (STAGES), Educate Girls, End Poverty (EGEP) and Kenya Equity in Education Project (KEEP) projects, men were more likely to have heard or received broadcast messages, which may be associated with gendered ownership and access to mobile phones and radios. Whilst reaching men is essential as they often make household decisions, more work is needed to find ways to reach women and girls. STAGES used voice rather than text messages to reach illiterate parents in rural Afghanistan. KEEP Kenya broadcast radio shows in local languages in refugee camps and host communities, with a "beep to vote" feedback mechanism, whereby listeners call a number and hang up to represent their views at no cost. These numbers were then used by the project for follow up. Evaluation suggests that the locally targeted radio shows had a positive effect, as part of a broader set of interventions.

The Tiphunzire Malawi Project organised Community Listening Clubs for the promotion of gender equality, sexual and reproductive health and the benefit of investing in girls' education

for families. During this time, the community would gather to listen to and discuss Tisinthe (Let's change!) a radio show that challenged social norms that restrict girls' rights and promoted gender equality and education through interactive drama. The audience could also participate in the radio shows through SMS. By gathering as a community there was an opportunity for discussion. Evaluation suggests this approach helped changed parents' perceptions.

Media/technology has significant potential reach and impact, but it is hard to measure

Several projects used TV, radio and mobile messaging to reach a broader audience with messages around the importance of girls' education, health and hygiene issues. Discovery broadcast chat shows in Kenya, Nigeria and Ghana, which reach significant national and regional audiences. The project reported that a market study in Kenya found the show was the third highest watched nationwide, although it's more difficult to know whether it reached the project's more specific target audiences of families and communities with marginalised girls. Although it is difficult to assess the impact, this national reach is significant and could influence public dialogue and social norms towards girls' education.

Health Poverty Action's project in Rwanda project partnered with a local organisation to contribute to an established national, interactive drama broadcast weekly on Radio Rwanda. This reached national audiences of around 7 million. Combined with other local advocacy and behaviour change communications, evaluation suggests that this has been an effective way to influence change. However it has been hard to attribute or measure the impact, as both control and intervention audiences were equally exposed.

Relief International's Educate Girls End Poverty (EGEP) project in Somalia included a significant component of awareness raising, using radio and other approaches. Evaluation found that radio and TV messaging has been effective in changing behaviour, but with limited reach in rural areas where other methods are more effective.

Technology can support other interventions, which help build life skills and confidence

Many GEC projects ran girls clubs and other activities to give girls opportunities to learn life skills, build their self-esteem and confidence and raise aspirations (see Extra and Co-Curricular Learning thematic review). Some of these used technology to support the interventions. Wonder Women clubs under the MGCubed project used the same live satellite technology as the project's maths and English classes to deliver life skills and mentoring clubs for both in and out-of-school girls, including interactive sessions with female role models. These clubs were found to be useful, particularly for out-of-school girls, for their practical content and the exposure to role models. The technology particularly facilitated girls in rural areas being exposed to new ideas and skills. Other projects used video or internet-based materials to provide content for girls' club discussions. EGEP Somalia used video editing classes for girls to develop, script, produce and film videos on girls' education. This approach, developing relevant local content, aimed to build girls' confidence and engagement. SOMGEP Somalia also used media/internet access for Girls Empowerment Forums and found with

increasing exposure to information on different roles for women, girls developed aspirations and perceived value in delaying marriage in order to pursue business or career plans. These approaches worked in synergy with other work with parents and communities.

How do we assess the cost and Value for Money of ed-tech interventions?

The GEC Fund Manager collected value for money (VfM) metrics for all projects and has provided an economy analysis for each year of GEC implementation. This economy analysis has employed a methodology to capture unit costs of GEC outputs including overheads, but it has not yet been possible to analyse VfM more completely, to include efficiency and effectiveness. Given the broadly mixed results from ed-tech interventions at the end of GEC1, it is hard to conclude that VfM has been achieved without more time for implementation. Within these constraints, we outline the range of project costs and set out considerations for a potential VfM framework.

The main costs of ed-tech: The costs for ed-tech interventions can be summarised as including: equipment/hardware; maintenance and replacement; establishing and maintaining connectivity; electricity; and other infrastructure costs to upgrade/maintain security, provide a room, etc; content development and provision; and training and staff support. Some of these are upfront capital costs, others are recurrent costs; some are more obviously driven by the number of schools and others are centrally driven and would substantially reduce if scaled to more schools. It is helpful to disaggregate costs on a per school basis, enabling comparison with government spending on schools. Inevitably, the per capita costs are higher for small, rural schools than larger urban schools. An illustrative overview of the range of costs per school includes:

- Provision of technology equipment from as low as £50 per school (e.g. devices for teachers). Average costs of deployment were high in the first year of GEC, at around £6000 per school, reducing to £433 per school in the final year.

- Cost of content provision varies greatly across the approaches adopted, including lesson development, registration fees, online materials and portal hosting costs, and DVD libraries. Per school costs for projects range from less than £1000 to over £3000

- The economy analysis shows a wide range of teacher training costs, depending on the models used. Ed-tech projects have adopted varied approaches, including distance learning models, so this needs more in depth analysis not possible for this paper.

We can see that potential up-front costs per school of an intervention of this kind can be high. More analysis may indicate ways in which such costs can be kept at affordable levels, but we also need to consider the timeframe over which such costs are assessed.

Assessing the value for money of ed-tech investments: VfM analysis needs to take into account the impact on learning outcomes and whether/how the project reaches the most marginalised girls. To assess VfM for ed-tech investments, some considerations should be:

- Proven benefits for student and teachers: student learning, retention, motivation, and “twenty first century skills”; teacher motivation, engagement and skills.

- Equity benefits: focus on the most marginalised, reducing inequality. Costs increase with the degree of marginalisation, when providing ICT to marginalised communities.
- Specific benefits and costs of services: where content or provision of access requires licencing or other fees, VfM analysis needs to look at development and on-going costs and who pays for these over the short/long term.
- Long term and sustainability benefits: how up-front investments (infrastructure, hardware, software, training) pay out beyond the project timeframe. Outcomes may improve over time as students and teachers become familiar with the technology.
- Longer term cost reduction: demonstrate that high start-up costs will be reduced and recuperated over time and that scaling up should also reduce per capita costs.
- Catalytic benefits: technology may create benefits beyond the immediate programme parameters (e.g. reliable internet to unconnected regions, or stimulating enterprise, contributing to the demand for skills in the locality).

This kind of deeper analysis remains a gap in GEC analysis of ed-tech interventions. The Evaluation Manager endline reports (Coffey, 2017) indicate some of the challenges in this, with limited available data. Where projects have had mixed results (learning and attendance), a broad conclusion is that project design and delivery will need to be improved in the next phase of support to ensure VfM is achieved.

Sustainability for ed-tech interventions is still uncertain

For ed-tech interventions, achieving sustainability includes two broad dimensions:

- The continued provision, development and maintenance of equipment, learning materials, or software and data systems
- The ongoing capacity building of teachers and other stakeholders to use, maintain and adapt (e.g. through creating/sharing content) these approaches to ensure children continue to benefit.

It may be possible to sustain the benefits at project schools without scaling up, while other models may rely on the buy in and support of government. At endline, there is no evidence that GEC ed-tech projects are sustainable; all need more time and effort to become so, and it is likely that only certain aspects of these interventions will be sustained. As highlighted in the GEC Evaluation Manager endline analysis (Coffey, 2017), GEC projects will need to address some design or delivery challenges in order to achieve this. We must also be clear that an ed-tech intervention is only worth sustaining if it can demonstrate that benefits are being delivered with value for money; if this is not the case, then potentially resources could be better used elsewhere.

Key lessons learnt on improving the sustainability of ed-tech interventions are explored in the next section.

5. Key lessons

Based on the existing literature and experience, we know that the use of technology in schools needs to be part of a broader approach to improving teaching and learning processes and content. Drawing on the GEC endline evaluations and other sources allows us to identify some key lessons on the use of ed-tech to improve attendance and learning.

Lesson one: There are a range of additional barriers to the implementation of ed-tech interventions, however these can be overcome

GEC projects using ed-tech had to overcome a range of challenges related to infrastructure, logistics and operations, which are often seen as a barrier to using technology in rural, remote and marginalised schools. However, these can be overcome or addressed, and some methods of doing this are explored below.

Bringing connectivity to remote schools may require new partnerships: A number of GEC supported interventions are based in marginalised and rural communities not previously connected to the internet. GEC brought in the private sector expertise of Avanti (iMlango) and Ericsson (Connect to Learn) which enabled this to be addressed in rural schools in Kenya and Myanmar. Significant upfront investment in the ICT infrastructure was required, and as a result these schools now have broadband access. Similarly, MGCubed used satellite internet connectivity and solar power to transmit their interactive distance learning classes to remote areas. Mobile coverage is limited in many remote regions and these projects all show that it is possible to find solutions that could work in low bandwidth environments.

Schools need electricity, infrastructure and secure storage for equipment. Communities can help find solutions: Some projects had to assess the electricity supply to schools as a criterion for selection. Ericsson Myanmar conducted a needs assessment in each participating school to check for reliable electricity supply, readiness for connectivity and ability to store equipment. This enabled the project to work with schools to develop appropriate solutions, including the provision of solar panels where needed. The Discovery evaluation noted that the supply of electricity in the participating schools became more reliable during implementation with schools possibly incentivised to resolve power supply problems. Communities provided financial or other material support to schools to maintain and improve Learning Centres, including the repair of equipment, electricity costs or ensuring security arrangements are in place. For the iMlango project communities also contributed extra funds to pay increased bills and maintain electricity supply. However, problems with electricity supply still resulted in disruptions to the use of equipment in class. These are real challenges in the use of ICT in schools, and need to be considered carefully at design stage. A key design risk is to provide ICT based learning only in better off schools, with the existing infrastructure; unless provision is made to help schools meet minimum requirements.

Schools also need to be able to secure any ICT equipment against theft or damage. The most marginalised schools may not be able to accommodate this kind of equipment, and may not have sufficient rooms to allocate for a computer lab or specific learning resource centre. A lesson from all projects was to ensure a sense of community ownership and support for the equipment. Discovery Girls worked with communities to contribute to the Learning Centre.

MGCubed worked with communities and schools to ensure security was organised to avoid theft of equipment. Connect to Learn helped schools upgrade rooms to ensure they were safe and secure to house equipment overnight.

Bureaucratic constraints need to be factored into project start up: It took significant time for Ericsson to secure approval from the Ministry of Communications and Information Technology in Myanmar, as the first such education project in the country. Avanti's deployment of hardware was delayed due the additional clearance required from the Kenyan government. These examples demonstrate that it is important to anticipate delays at a ministerial level, particularly because of the more innovative or less conventional type of offering within an education technology programme.

Lesson two: Data needs to be well-integrated and stakeholders need to be engaged to support the collection and use of reliable data

Reliable school data needs to be well-integrated to be effective: GEC endline reports highlighted the importance of actively embedding school management data within a broader programme. The Jiemelishe evaluation explains how attendance data tracking was a component within a holistic programme, in which attendance has also been influenced by the other direct outputs within the project to address demand side constraints. A similar experience was noted in the PEAS evaluation, where the school management system was one of approximately twenty different project activities and the endline evaluation noted that it had played a contributory role within the system.

The GEC includes some projects that have generated data on student learning, such as iMlango through its use of Maths Whizz and regular on-line literacy tests. However, endline reports have not shown how this data is being used to make a substantive shift in approach to teaching and learning. The Discovery project also found it hard to track the use of its video library due to reliance on paper-based reporting by teachers, making usage data unreliable and making it hard to know how resources are being used. More work is needed under the GEC to capture and use learning data in ways that can help schools, and in particular head teachers, to drive improvements in learning.

Local stakeholders need to be engaged and see the value of technology in generating reliable data: Projects found that there is a need for sustained effort in providing training and support to ensure data is well used. In iMlango, the majority of head teachers reported finding attendance reports useful for identifying children at risk of dropping out and so following up with them and their families. Camfed also reported similar findings and note that their mobile data collection system increased stakeholder engagement, for example with local education authorities. The system is used by various stakeholders, but the data is managed at a project level rather than at the school level or within a national EMIS.

A feature of the biosim system used by Jiemelishe that has been seen to be most effective was the message sent to parents each day to confirm their children's arrival and attendance at school, increasing their engagement in the school and their confidence in the safety of their children. However, the evaluation also noted that in some locations community distrust and misinformation hindered implementation.

Lesson three: Students need access to the hardware and ed-tech content, supported by sufficient time spent on task

Individual students or whole classes need sufficient time on the devices, either in class or after school. The iMlango evaluation shows that the project succeeded in establishing the functionality and use of the learning portal and materials within schools and that where children received sufficient time on task with the individualised learning programmes, the results are good. However, for most students, access to computer labs and individualised learning time across a range of learning resources was insufficient to have a transformative effect. This was partly due to the large class sizes, limited number of devices and availability of teachers to oversee students using equipment, and the logistics of ensuring equipment for whole class teaching were in place at the start of a class. At endline, the project estimated that to achieve the target progress rate for numeracy, student usage of Maths Whizz needed to exceed 59 minutes per week. Less than 5% of students achieved these rates, but those who did achieved more rapid and significant learning outcomes. Interestingly, the evaluation indicated that the counties where students spent most time on Maths Whizz, were those where teachers were observed to be most engaged with their students, indicating that teachers may be encouraging student use of ICT for learning. The project also presented data to show gender differences in usage targets, with fewer girls getting the required amount of access to the technology. In response, iMlango worked with schools to redress this imbalance and will continue to do so in the next phase of the GEC, potentially targeting time in computer labs to specific grades.

This reflects a need for stronger classroom management and access to hardware when using technology for learning. Project data indicates that students from more marginalised backgrounds made slower progress than expected from their initial exposure, then progressed more rapidly when given additional time on the programme. Time on task is, therefore, especially important in order to establish a good learning trajectory in contexts where many students have little prior exposure to technology.

Lesson four: It is important to support teachers to use technology *and* use technology to support teachers

Project experience confirms the need for in-depth, well planned training for teachers in order to use technology effectively, supplemented by on-going, in-school support. This was found to be needed more than was originally planned for. Child Fund Afghanistan provided mobile learning in adult literacy to school committee members, and found they had under-estimated the need for training and support for their Social Mentors who were leading the intervention. Under iMlango, teacher training gave an early focus to reassuring teachers that technology is not a threat but an opportunity to develop their career and make learning more interactive, enjoyable and effective. However, the evaluation found teachers needed more in depth and sustained training to ensure they could utilise the technology effectively.

For iMlango, it was critical to establish teacher usage of the on-line resources, and teachers then became more confident in using technology for whole class teaching, for example providing nearly 90,000 students with individual log-ins and ensuring they had undertaken Maths Whizz assessments. Nonetheless, evaluations still found that some teachers are not confident, for example 22% of teachers in iMlango schools were not using digital tools for

whole class teaching even after training. This indicates the need for sustained support, or points to broader challenges faced by teachers in some schools (e.g. large class sizes, poor condition of facilities). There is evidence from both iMlango and Connect To Learn that teachers used the internet for lesson preparation. However, while Connect To Learn teachers used technology for lesson planning, previous teacher centred pedagogy remained prevalent.

The Discovery evaluation indicated how teacher training, observation and follow up has led to improved teaching practice, with more child centred and gender sensitive pedagogy in use among intervention schools (e.g. variety of activities used in class, group work, actively involving non-participating students). However, the broader GEC evaluation (Coffey, 2017) highlights some caution over the extent to which these results show change over time. The results also seem to show more use of these approaches in the Learning Centres (i.e. classes using video-based learning) than in regular classes in the same schools. Introducing the technology itself will not change teaching practice without a significant effort to train teachers, provide on-going support. This is the same as those teacher interventions that do not involve technology.

In remote/rural schools, where teachers are often isolated and have limited in-service support, distance learning and broadband platforms can support teachers' pedagogical content knowledge and skills. MGCubed reported a number of ways in which teachers in rural schools have benefited. Qualitative research at endline highlighted "dual instructor presence", referring to the fact that students in MGCubed classes benefited from both the Master Teacher via satellite, and the in-class teacher. Not only did this support learning, as it essentially halved the student teacher ratio, but it also benefitted the classroom teacher whose teaching skills were enhanced by seeing good practice modelled. The evaluation also indicated that the project classes were more engaging and interactive, and that this approach is having a spill over effect on teachers in their other classes. Qualitative research also suggests that teachers/facilitators for project classes demonstrated improved classroom management skills and motivation more broadly, and that attendance levels of teachers were better in these classes than normal in rural schools.

Where teachers have access to the internet, they are using this to research and source teaching materials or improve their own knowledge. Both Discovery and iMlango evaluations indicated that teachers' confidence improved, and teaching was made easier by the use of online content, particularly in teaching abstract concepts. However, more research is needed into the materials they are accessing and whether this is contributing to improved teaching. More research is also needed to assess how to support teachers to improve their content knowledge when they lack the basic skills they are meant to be teaching.

World University Service of Canada's (WUSC) project in Kenya gave teacher coaches tablets with preloaded learning materials, and Red Een Kind's (REK) South Sudan project used audio recordings to provide teachers with methodology and intensive English training. There is little from the evaluations to suggest these led to increased learning by students, but there is evidence that teachers found this technology useful and effective in support of their teaching. Qualitative research from the Discovery evaluation suggests that teachers were motivated by the technology and high quality content to better plan lessons around meaningful and relevant activities and discussions.

Teachers have also been supported through social media and networking. Camfed set up an internal Social Education Network for peer support among their mentors. It is likely that this network of support between these mentors contributed to the strong project learning results. The main platform for this networking seems to be teachers connecting through WhatsApp groups and other free messaging services, rather than the project's internal network, which came with higher costs for users. Project mentors and district coordinators used these social media groups to stay in touch with and provide guidance to trainees. This was also noted by the KEEP project in Kenyan refugee camps, where independent research conducted in project schools found that teachers established peer-based support, sharing experience, tools and resources (Dryden-Peterson et al, 2017).

Lesson five: Learning content needs to consider the language needs of students

Where interventions aimed to use the internet to open up new teaching and learning materials to students, there was a need for materials which are both language and curriculum appropriate. Several endline evaluations noted that content provided through internet-based learning platforms is often in English or languages other than mother tongue.

The iMlango project used English as the language of instruction, and is looking at ways to adapt online materials, including the possible use of Kiswahili for maths instruction. While the Discovery Girls project adapted English language materials into Hausa, Swahili and Somali, the evaluation noted that the language of materials may still have played a role in limiting the effects of the project seen in endline learning assessments. The Connect to Learn project focused on secondary schools in Myanmar where English is a language of instruction in upper grades, but found few Myanmar language materials or apps for use on the learning portal. Interventions therefore needed to consider government policy in terms of language of instruction, as well as the broader availability of content in languages that can be accessed by students and teachers, particularly if the theory of change assumes broader availability of content will improve learning.

Lesson six: A number of methods could improve sustainability of ed-tech interventions in the GEC

Some key lessons at GEC1 endline on the sustainability of ed-tech interventions include:

Build local ownership and look for ways to generate local funding: A number of GEC projects noted how they engaged with community and school stakeholders to build a sense of ownership and an understanding of the benefits being brought to the school. Several projects received financial or other material support from communities to improve and/or maintain facilities indicating good local buy-in that will be central to sustaining the models in future. However, the Evaluation Manager endline reports indicate a key risk where some local communities are not able or willing to raise funds.

The iMlango project tested different ways to provide connectivity to the local community in a way that will bring broader benefits, but also generate revenue to cover on-going maintenance costs. This would not have covered the initial investment, but may over time facilitate sustainability at a local level, and is planned to be extended in the next phase of the project. The PEAS Uganda project saw the benefits of a technology-based approach to data

management, but as a chain of low cost private schools, each school needs to be self-sustaining. The project is uncertain that even a relatively simple approach is sustainable if the start-up and maintenance costs are not justifiable.

Be clear what is needed at the system level and whether/how to scale up: Most projects reported some positive achievements in terms of broad support and engagement with government and other system stakeholders, including district/local authorities and national Ministry of Education staff. Projects involved government in delivering training, support and monitoring as well as ensuring teaching and learning materials were aligned to national curriculums. However, this has not generally translated in to more concrete plans. For Discovery, government stakeholders were highly supportive of the intervention and approach but could not articulate specific plans to carry on and sustain the work. Despite no longer being part of the GEC, Ericsson will continue to support the schools it has worked with, signalling at least short-term sustainability via the private sector while engagement from the Department of Education in Myanmar continues.

The iMlango project has an important opportunity in Kenya with the roll out of a government Digital Literacy Programme which is providing tablets to all schools. The project is working to ensure intervention schools can optimise this new investment to make the most of iMlango learning content and teaching approaches, as well as hosting government learning materials. This presents opportunities for iMlango to demonstrate added value. iMlango content development and hosting come with certain costs, including Maths Whizz licenses, managing a learning portal, or attendance tracking systems. It may be possible to sustain aspects of the project at local/school levels, but for broader roll out and benefits it will need policy and financial backing from government.

MGCubed has demonstrated the potential added value in learning gains for disadvantaged rural schools. Certain capabilities may have been strengthened in project schools that could continue in the future. However, the sustainability of the model will require funding and support for the central studio and continuation of distance learning as well as using this as a model to support teachers. Ultimately this requires the support of the Ghana Education Service, as a policy response to the needs of rural schools, as a mechanism for providing in-service professional development to teachers, and either government or other sources of funding over the longer term.

Ensure teachers and head teachers are at the heart of sustainability plans: Discovery trains Resource Teachers who then train others along with the provision and use of video-based teacher training materials. MGCubed is using distance learning to focus on teacher capacity and in-service training. Other projects have used technology to provide a range of materials to teachers, online or through off-line devices. Projects noted the importance of head teacher buy in and support, including for the use of data management systems to improve teaching and learning and the targeting of support to at-risk children. A key area not specifically addressed in GEC endline evaluations is the involvement of teachers in the design, creation and sharing of learning materials. This can be facilitated by teacher networks, as seen under GEC projects in Kenya (WWW, KEEP), and Zimbabwe/Tanzania (Camfed). A challenge related to all interventions that train teachers, is the regular transfer of teachers from project

schools, which undermines sustainability unless either school or system level responses can ensure some continuity of the project's approach.

There is a role for the private sector to ensure connectivity and technology services: The GEC partnership with the private sector shows significant benefits in fast tracking access to technology where schools currently lack the necessary infrastructure and capacity (iMlango, CTL). Under iMlango, Avanti Communications provided connectivity to rural schools in Kenya, while developing their broader place in the Kenyan communications market. The GEC tested an expectation that the private sector would find sustainable ways to support girls' education where market driven approaches had financial payoffs. This has not yet happened, as none of the private sector partnerships were designed with business models that would fully sustain GEC interventions without continued donor or other external funding. However, engaging the private sector has extended connectivity and brought new approaches to provision of high quality content and data management that would not have been made available to disadvantaged schools before.

Lesson seven: Focus on developing high quality learning content and curriculum materials and improving access to them

GEC projects have had to work hard to identify or create appropriate content that was of sufficient quality, relevant to local and country contexts, appropriate for target grades and subjects, and in line with the country's national curriculum. Finding efficient and effective ways to access and screen content was vital, as was gaining appropriate approvals from curriculum authorities which may have limited capacity to evaluate the efficacy of digital content (e.g. iMlango, Connect to Learn). Without dedicated expertise, some projects struggled to find appropriate and approved materials, especially content that could be used off-line (e.g. PEAS, CRANE). However, there were some examples of content development:

- iMlango provided a range of online content that was not previously available to students and teachers in their schools, including the individualised learning under Maths Whizz, literacy and life skills materials. The ability of the Maths Whizz tutoring approach to assess and tailor content to the specific learning needs of each student combined with an engaging mode of delivery appears to have potential for both foundational and remedial learning. iMlango used this to help teachers identify precise numeracy which students struggled with, and to adapt whole class teaching, though the evaluation suggests that teachers did not apply this consistently and effectively.

- MGCubed focused significant effort on the design of content based on the national curriculum. The project taught only selected groups of children in each school, in multi-grade basic and intermediate streams, adjusting content and teaching to the appropriate level. When midline assessments showed no improvement in literacy scores compared to the control group, the project modified English literacy content to boost literacy learning. In addition, lesson observation and assessment data were used to make adjustments to teaching practice and lesson planning to align with improved content. This illustrates the application of good teaching practice to the context of technology enabled lessons. The evaluation suggests that the project was able to focus on ensuring the lower ability students achieved basic foundational skills.

- Discovery provided a library of video-based teaching and learning materials mapped to the curriculum of each of their three countries. The evaluation noted that many of these materials focused on science and social studies subjects, and to a lesser degree on maths and reading; the project may have had an unrecorded effect on other knowledge/skills areas that were not assessed. Under the next phase, the intention is to develop more literacy and numeracy focused content.

6. Considerations for practitioners and policy makers

The GEC provided a useful testing ground for a range of ed-tech interventions. A central theme of this report is that ed-tech can be integrated into a range of interventions, whether in classroom learning, school management or broader strategies around girls' education. However, the GEC is not yet in a position to make strong claims around how such work can lead to improved outcomes.

At the start of the paper, under the brief review of research and evidence, a simple framework of good practice was presented. Using this framework, we assess below what has been learned and identify implications for project design and delivery; this could be a basis for developing minimum standards for the design of ed-tech interventions.

Respond to context:

- Rural and disadvantaged schools face significant challenges delivering quality teaching and learning and addressing demand side challenges faced by girls' families. Ed-tech has been used by some GEC projects to respond to these challenges, including providing distance training/support to teachers, and helping schools meet the basic infrastructural needs to employ technology solutions.

Recommendation: Specific attention should be given to designing and adapting approaches that can enable the use of technology for rural schools, particularly for teacher development/support needs. A focus should be given to building evidence to show how this can be done in a cost effective way that could be supported at scale. Significant attention is also needed to assess the basic infrastructure needs of schools, and where possible help schools to meet a basic level to enable the use of technology, or apply technology solutions appropriate to this context (e.g. solar, off-line, etc.)

- Gender equity and social inclusion challenges have not been systematically addressed under all GEC ed-tech interventions. While the introduction of technology in schools may not be responding to specific gender barriers, there is a risk that girls will benefit less from technology-based learning resources, unless teachers understand gender equity and address it though their classroom management.

Recommendation: Where ed-tech is introduced, gender and social inclusion analysis and on-going monitoring should inform design and delivery to ensure all children benefit equally.

Projects should give specific consideration to the design of ICT based learning materials and support for children with disabilities.

- Several GEC projects have worked with local and national authorities and mapped learning content against the existing curriculum, as a basis to ensure local buy-in and recognition of the value and potential of technology-based approaches.

Focus on educational outcomes:

- GEC experience confirms that ed-tech interventions need to have a strong focus on high quality, locally appropriate learning materials with clear learning objectives, and a robust theory of change around how these will be used by teachers and students. This seems obvious, but experience shows it can be complex to deliver, particularly if assumptions around the implementation at school/classroom do not hold.

- Training for teachers is critical, both in terms of pedagogical approaches and in classroom management which ensures student time on task is optimised, and this training needs to be in depth and sustained over time. Interventions should also be clear about the expected change in teaching practice; technology itself will not bring about such change but can enable enhanced support to teachers. Mobile technology and associated use of social network and messaging apps are becoming more prevalent and some projects have seen benefits for teacher peer support.

Recommendation: Ed-tech interventions which aim to improve classroom learning should demonstrate a clear theory of change at the centre of which is appropriate and good quality content, with adequate training and support for teachers. Use of existing mobile technology, including social networks, should be considered for building low cost models for teacher peer support.

- GEC projects have also confirmed that at least in the early years of implementation, the introduction of technology can have motivating effect on teachers and students, but a key challenge may be how to sustain this over time.

Recommendation: Project monitoring should track the extent to which the effect of technology on student and teacher motivation and engagement can be sustained over the medium to longer term.

- The GEC has provided several innovations in the use of ed-tech to provide significant and more reliable data for school management. Some anecdotal evidence suggests this helps track and encourage student attendance. In some cases, real time data on learning is being captured and used by schools. However, these approaches have not shown their full potential and some challenges in the evaluation (e.g. comparing data from intervention and control groups) have limited the analysis of results.

Recommendation: Subsequent projects should build on these approaches, ensure real time data on learning and attendance is systematically captured and used at school/project level, and analyse the links between attendance and learning.

Develop systems and capacity:

- Building on good context analysis and understanding of national curriculum and systems, GEC projects have engaged well with authorities, and endline evaluations recognise the broad support from governments. However, this has not yet translated into firm plans for longer term integration. A key challenge noted by some ed-tech projects has been the timeframe in which an intervention could become sustained in terms of cost/funding. Other work has focused on building school/community level capacity to maintain and use the equipment, content and teaching approaches delivered through project support. There are many challenges to this, including the regular transfer/turnover of teachers, and the mixed ability of local communities to fund the additional maintenance/electricity costs.

Recommendation: Sustainability plans need to take a realistic, long term approach to establishing ed-tech interventions both at national/system level and within project schools. Plans should be premised on demonstration of outcomes and value. A key area of work is in ensuring school and community leadership and buy in, and building sustainable networks of support among teachers.

- Projects across the GEC have had to develop child protection policies and approaches, and this has been monitored systematically throughout GEC implementation. However, more work is needed to capture lessons and joint approaches to ensuring digital security and child safeguarding in the context of ed-tech projects.

Recommendation: Practitioners should seek to undertake joint learning on specific good practice and minimum standards for digital security and child safeguarding where technology is being used with students and teachers.

- The GEC has contributed some important lessons in engaging with the private sector to bring technology capability and innovation. A key opportunity is to provide incentives for market entry that can support marginalised communities/schools that would not otherwise have access to connectivity and digital hardware/content. More work is needed to understand the best models for partnering with the private sector in ed-tech innovation in education, and how DFID should fund this.

Recommendation: Consideration should be given to how private sector partnerships can be harnessed to reach the most marginalised, including remote/rural schools, and attention paid to the costs and benefits of providing high quality content. Given this may lie beyond the control of specific projects, these lessons should inform DFID, other donors and governments about how to engage the private sector and how this can be done at a sustainable cost. This work sits beyond the expertise of the education sector, and requires more joined up work within development agencies and across government departments.

References

Center for Education Innovations (2014) *Education Technology Database at a Glance.* Available from: http://educationinnovations.org/sites/default/files/CEI%20Education%20Technology%20DAG.pdf [Accessed 9 March 2018]

Center on Online Learning and Students with Disabilities (2018) Available from: http://www.centerononlinelearning.res.ku.edu/center-reports/ [Accessed 9 March 2018]

Coffey (2017) Girls Education Challenge (GEC) Endline Evaluation Reports: Strategic Partnerships Window; Innovations Window; Step Change Window. Available from: https://www.gov.uk/guidance/girls-education-challenge#endline-evaluation-reports [Accessed 9 March 2018]

Cristia et al. (2012)*Technology and Child Development: Evidence from the One Laptop per Child Program.* IDB WORKING PAPER SERIES No. IDB-WP-304. Inter-American Development Bank February 2012. Available from: http://repec.iza.org/dp6401.pdf [Accessed 9 March 2018]

Department for International Development (DFID) (2010) *Education for children with disabilities: Improving access and quality.* A DFID practice paper. Available from: https://www.gov.uk/government/publications/education-for-children-with-disabilities-improving-access-and-quality-guidance-note-a-dfid-practice-paper [Accessed 9 March 2018]

Dryden-Peterson et al. (2017) *How teachers use mobile phones as education tools in refugee camps.* Available from: https://www.brookings.edu/blog/education-plus-development/2017/03/14/how-teachers-use-mobile-phones-as-education-tools-in-refugee-camps/ [Accessed 9 March 2018]

English in Action (EIA)(2014) *Classroom practices of primary and secondary teachers participating in English in Action: Second cohort* (2013). Research report, English in Action, Dhaka, Bangladesh. Available from: http://oro.open.ac.uk/42304/1/upscaling-phase_download%3D61_classroom-practices-of-primary-and-secondary-teachers-participating-in-english-in-action-second-cohort-2013 [Accessed 9 March 2018]

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2016) *Education in Conflict and Crisis: How Can Technology Make a Difference? A Landscape Review*. Available from: https://www.giz.de/de/downloads/giz2016_en_Landscape_Review_ICT_in_Conflict_and_Crisis.pdf [Accessed 9 March 2018]

Gladwell et al. (2016) *Higher education for refugees in low-resource environments: landscape review.* Jigsaw Consult, United Kingdom. Available from: https://jigsawconsult.com/sites/default/files/files/Jigsaw%20landscape%20review.pdf [Accessed 9 March 2018]

Global Business Coalition for Education (2014) *Towards a Global Education Platform: Potential Models for Harnessing Technology to Promote Education as a Global Public Good.* September 2014. Available from: http://gbc-education.org/wp-content/uploads/2015/05/GEP-report.pdf [Accessed 9 March 2018]

High-Quality Technical Assistance for Results (HEART) (2013) *Helpdesk Report: ICTs and Education*. Available from: http://www.heart-resources.org/wp-content/uploads/2013/10/ICTs-and-Education.pdf [Accessed 9 March 2018]

Institute for International Cooperation and Development (IICD) (2015*) ICT and education: case study of Zambia.* Available from: https://iicd.org/documents/c4c-ict-for-education-study-lessons-learned-report/ [Accessed 9 March 2018]

mEducation Alliance (2017) Available from: http://www.meducationalliance.org/?page_id=59 [Accessed 9 March 2018]

Massachusetts Institute of Technology (MIT) (no date) *A framework for evaluating appropriateness of educational technology use in global development programs*. Available from: http://cite.mit.edu/system/files/reports/Summary%20Report_A%20Framework%20for%20Evaluating%20Appropriateness%20of%20Educational%20Technology%20Use%20in%20Global%20Development%20Programs.pdf [Accessed 9 March 2018]

Muyoya, Brugha, & Hollow (2016) *Education technology map: guidance document*. Department for International Development (DFID). Jigsaw Consult, United Kingdom. https://jigsawconsult.com/sites/default/files/files/Education-technology-evidence-mapping-guide.pdf [Accessed 9 March 2018]

Organisation for Economic Co-operation and Development (OECD) (2015) *Students, computers and learning, making the connection*. Available from: http://www.oecd.org/education/students-computers-and-learning-9789264239555-en.htm [Accessed 9 March 2018]

Piper & Kwayumba (2014) *USAID/Kenya Primary Math and Reading (PRIMR) Initiative: Kisumu Information and Communication Technology (ICT) Intervention*. Endline Report. Available from: https://globalreadingnetwork.net/eddata/usaidkenya-primary-math-and-reading-initiative-kisumu-information-and-communication [Accessed 9 March 2018]

Piper & Mugenda (2014) *USAID/Kenya Primary Math and Reading (PRIMR) Initiative*. Endline Impact Evaluation. Available from: https://globalreadingnetwork.net/eddata/usaidkenya-primary-math-and-reading-primr-initiative-endline-impact-evaluation-revised [Accessed 9 March 2018]

Porter (2016) *Mobile Phones and Education in Sub-Saharan Africa: From Youth Practice to Public Policy.* Available from: http://onlinelibrary.wiley.com/doi/10.1002/jid.3116/full [Accessed 9 March 2018]

Severin et al.(2011) *Evaluation of the 'Una Laptop Por Nino' program in Peru: results and perspectives.* Available from: http://www.heart-resources.org/doc_lib/evaluation-of-the-una-laptop-por-nino-program-in-peru-results-and-perspectives/ [Accessed 9 March 2018]

Trucano (2015) *Key themes in national educational technology policies*. Available from: https://blogs.worldbank.org/edutech/key-themes-national-educational-technology-policies [Accessed 9 March 2018]

Trucano & Dykes (2016) *Building and sustaining national ICT education agencies: Lessons from international experiences.* World Bank Education, Technology & Innovation: SABER-ICT Technical Paper Series (#02). Washington, DC: The World Bank Available from: https://openknowledge.worldbank.org/handle/10986/26086 [Accessed 9 March 2018]

Trucano (2016) *SABER-ICT Framework Paper for Policy Analysis: Documenting national educational technology policies around the world and their evolution over time.* World Bank Education, Technology & Innovation: SABER-ICT Technical Paper Series (#01). Washington, DC: The World Bank. Available from: http://wbgfiles.worldbank.org/documents/hdn/ed/saber/supporting_doc/Background/ICT/112899-WP-SABER-ICTframework-SABER-ICTno01.pdf [Accessed 9 March 2018]

United Nations Children's Fund (UNICEF) (2013)*The State of the World's Children 2013. Children with Disabilities.* Available from: https://www.unicef.org/sowc2013/focus_assistive_technology.html [Accessed 9 March 2018]

United Nations Educational Scientific and Cultural Organization (UNESCO) (2014) *Reading in the mobile era: A study of mobile reading in developing countries.* Available from: http://unesdoc.unesco.org/images/0022/002274/227436E.pdf [Accessed 9 March 2018]

Unwin (2009) *ICT4D: Information and Communication Technology for Development.* Cambridge: Cambridge University Press

United States Agency for International Development (USAID) (2011) *First Principles: Designing Effective Education Programs Using Information and Communication Technology (ICT) Compendium*. Available from: https://www.usaid.gov/sites/default/files/documents/1865/E1-FP_ICT_Compendium.pdf [Accessed 9 March 2018]

Walsh et al. (2014) *Education Technology Topic Guide*. HEART. Available from: http://www.heart-resources.org/topic/educational-technology/ [Accessed 9 March 2018]

Walsh & Power (2013) The 'Trainer in Your Pocket': Mobile Phones Within a Continuing Professional Development Program in Bangladesh. Milton Keynes: *Professional Development in Education.* Vol 39 (2) pp. 186-200. Available from: http://www.tandfonline.com/doi/abs/10.1080/19415257.2013.766232 [Accessed 9 March 2018]

World Health Organisation (WHO) (2015) *Assistive Technology for Children with Disabilities: Creating Opportunities for Education, Inclusion and Participation.* A discussion paper. WHO and United Nations Children's Fund (UNICEF). Available from: https://www.unicef.org/disabilities/files/Assistive-Tech-Web.pdf [Accessed 9 March 2018]

Annexes

Annex 1: GEC project uses of technology

Type of input	iMlango* (Kenya)	MGCubed*(Ghana)	DG* (Ghana, Kenya,Nigeria)	CTL* (Myanmar)	Jiemelishe (Kenya)	WWW (Kenya)	Camfed (Tanz, Zimbaber)	REK (S. Sudan)	EGEP (Somalia)	KEEP (Kenya)	ChildFund (Afg)	CRANE (Uganada)	STAGES (Afg)	PEAS (Uganda)	Camfed (Zambia)	TFAC (Malawi)	REAP (Rwanda)	PAGES (Moz)	Sisters for Sisters (Nepal)	SOMGEP (Somalai)
Teaching and learning resources (software): content/resources for teachers and/or students	✓	✓	✓	✓		✓		✓			✓	✓								
Connectivity: internet access to schools	✓	✓		✓																
Management systems: ICT school data systems	✓				✓									✓						
Devices: hardware for learning/teaching, and attendance tracking etc	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓					
Training and support: support to teachers / stakeholders use tech	✓	✓	✓	✓		✓	✓	✓				✓								
Advocacy, awareness and life skills: share information, messages, build knowledge, etc		✓	✓						✓	✓			✓			✓	✓	✓	✓	✓
Monitoring and evaluation systems: hardware / software used M&E	✓				✓	✓	✓								✓	✓				

Annex 2: Illustrative education technology indicators

This table provides illustrative indicators from the GEC project logframes, showing how the use of education technology is being monitored. They are organised according to the three main objectives listed in the body of the report: support teaching and learning, improve school management, and promote awareness and advocacy around girls' education. The indicators are qualitative and quantitative, and are illustrative rather than comprehensive.

Indicators for assessing how education technology is being used to support teaching and learning.	Average exposure time to education content (on the learning platform) each week (Avanti, Kenya) Increased teacher self-perception about the value of ICT in the class (Ericsson, Myanmar) Regular use of ICT by teachers during school time for teaching and learning (hours using internet) (Ericsson, Myanmar) Percentage of lesson plans including bespoke digital curriculum content, encouraging student-centred activity-based learning (Varkey, Ghana) Percentage of girls from target schools reporting improved learning performance resulting from ICT based learning (ICL, Kenya) Percentage of lesson plans including bespoke digital curriculum content, encouraging student-centred activity-based learning (Varkey, Ghana) Number of schools where students are using installed school computers for educational self-study sessions outside of the school timetable (Varkey, Ghana) Improvement in maths age relative to Maths Whizz usage by students (Avanti, Kenya)
Indicators for assessing how education technology is being used to improve school management, data collection and reporting.	Percentage of schools disaggregated by region using information from enhanced learner attendance data collection systems to address girls' reduce absenteeism (ICL, Kenya) National adoption of initiatives to introduce technology for EMIS for planning (qualitative indicator) (Camfed, Zimbabwe / Tanzania) Proportion of head teachers who say the attendance data is useful in managing attendance issues (Avanti, Kenya)
Indicators for assessing how education technology is being used to promote awareness and advocacy around girls' education.	Improvement in parents' knowledge, attitudes or practices (KAP) related to girls' education (in project catchment areas) (DLA, Kenya / Ghana / Nigeria) Improvement in viewers' knowledge, attitude or practices (KAP) related to girls' education (DLA, Kenya / Ghana / Nigeria)

The Girls' Education Challenge is a project funded by the UK's Department for International Development and is led and administered by PricewaterhouseCoopers LLP, working with organisations including FHI 360, Nathan Associates London Ltd. and Social Development Direct Ltd.