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Building Digital Technology Capacity to Support Data Education in Edinburgh and South East Scotland Region Schools

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**Building Digital Technology Capacity
to Support Data Education in
Edinburgh and South East Scotland Region Schools**

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THE UNIVERSITY
of EDINBURGH

**DDDI
Skills
Gateway**

Table of Contents

Figures

Tables

Section 1: Summary and Recommendations

1   Context and Purpose of Report

The aim of Data Education in Schools programme, funded by the Data Driven Innovation Skills Gateway in the Edinburgh and South East Scotland City Region Deal, is to develop skills in data literacy for learners and teachers. **The purpose of this report is to recommend the appropriate digital technology infrastructure which is required to support the data education curriculum.**

The world of employment is predicted to change significantly in the future. It is anticipated that the need for some skills will disappear and the demand for other new skills and abilities will increase. As the use of automation and integrated technologies increases across all professional areas and working patterns shift, the skills profiles of different occupations are also likely to change.

Data will play an increasingly significant role in all aspects of our personal and professional lives. Ensuring that everyone has the awareness, skills and the critical data literacies needed to navigate its uses and affordances successfully is increasingly important.

Edinburgh has the ambition to become the Data Capital of Europe and is well-positioned to become so. It is currently home to the largest technology incubator hub in Europe, hosts the world-leading Edinburgh Parallel Computing Centre as well as data-driven hubs serving research innovation across the Health and Social Care, Public Sector, Financial Services, Fintech, Tourism and Festivals, Creative Tech, Agritech, Robotics and Autonomous Stems, Space and Satellite and Digital Tech sectors. It is predicted that as this sector grows substantially over the coming years, as many as 70,000 new jobs will be created.

The ambition is that all citizens of the Edinburgh City Region no matter their age, gender, background or ability will be **data citizens**, i.e. aware of how their personal data is used, their legal rights and privacy implications.

Equally, all citizens will have opportunities to acquire the data skills required to be competent and capable **data workers** within their chosen career. Training opportunities will exist via multiple routes for citizens to learn skills to use data to critically diagnose,
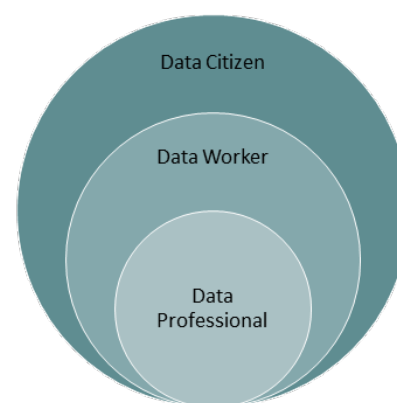
analyse, and predict trends and patterns, manipulate datasets and use data in a myriad of creative and communicative ways.

The need for **data professionals** who have the specialist skill set and knowledge to lead and steer organisations through a data-driven economy is key to its success. Ensuring that routes exist through each of these three tiers for all citizens of the city region to take advantage of these opportunities is a critical part of the ambition for the DDI Skills Gateway.

2   Consultations with Stakeholders

The groundwork for all three tiers of expertise – data citizen, data worker and data professional - has to begin with the region's schools, making sure that young people of all ages have the opportunity to engage with and develop the skills and abilities to use data effectively.

A significant strand of the DDI Skills Gateway is the Data Education in Schools programme which aims to support all schools across the region to offer a data education curriculum to its young people. Over the eight-year programme, the aim is that all 121,000 young learners across the region will have the opportunity to excel in data education regardless of gender, location, or background.

The Edinburgh City Region comprises of six Councils; City of Edinburgh, East Lothian, Fife, Midlothian, Scottish Borders and West Lothian. This report offers a comprehensive outline of the existing educational technology infrastructure across those six regions and has been compiled from several sources. The focus of the report is on the aspects of the infrastructure landscape, which are pertinent to the Data Education in Schools programme.

The report has synthesised information from several sources, and although not exhaustive, sources have included consultation with:

- 180+ pupils across 20+ schools in the region.
- Digital Learning Teams in each of the six city region Councils
- Council IT and Business Services staff in city region Councils
- Data Education in Schools team, Moray House School of Education and Sport
- CALL Scotland, University of Edinburgh
- Personnel in Education Scotland and the Scottish Government
- Academic and professional staff from the University of Edinburgh
- Contractors from partner organisations and businesses
- Survey data from individual Councils
- Existing published data from regional and national sources

The aim of this report is not to highlight the strengths or expose the weaknesses of individual Councils or

schools, but to assimilate the data gathered from a range of sources and stakeholders into a set of key findings and recommendations. These will support the development of a Data Education in Schools programme across the region over the next eight years.

3   Supporting Data Education in City Region Schools

High-quality data education in schools requires investment in technology in terms of software, access to datasets and specialist hardware. Such investments will benefit not only data education, but also STEM learning and the development of digital literacy across the curriculum which are both priorities of the Scottish Government.

The role of Data Education in Schools is to provide professional learning for teachers and data learning materials mapped to Curriculum for Excellence. Our professional learning is primarily focussed on the pedagogy of data education, although we will also provide some courses on specific technology skills for teachers as necessary. We also aim to provide a technology lending library for schools within the City Region, on the understanding that local authorities may wish to pilot the use of new technologies before investing further.

Technology should not be a barrier to a school which wishes to improve data education. It is possible to teach valuable concepts in "data unplugged" activities which do not use technology at all. However, to support all stages of learning within the data problem-solving cycle, all learners will need access to general-purpose computing equipment (i.e. spreadsheet software on tablets, laptop or desktop computers) and online datasets. As it can be difficult to comfortably work with larger data sets on a small screen without a keyboard and mouse, and because the analysis functionality available on tablet software can be limited, we recommend that schools provide laptop or desktop computers for larger data projects with upper primary or secondary learners. Secondary schools which offer computing and data science qualifications will require specialist software including programming language environments and commercial data visualisation packages.

4 Summary of Recommendations

The recommendations in full are included in section 2 of the report. The summary of findings across the seven areas considered are as follows:

4.1 Supporting specific tools for Data Education

Learners need access to software and hardware for collecting, analysing and presenting data. We recommend that Data Education in Schools and the Councils provide schools with:

- A range of local and online software tools, including spreadsheets, point and click data analysis tools, commercial visualisation tools, and programming environments for data science
- Access to a wide range of data sets for learners and teachers
- Access to Specific hardware, such as sensors and robots

4.2 Supporting Technological Environment: Connectivity, Coverage and Capacity

Connectivity is an enabler of learning and teaching through digital tools. There are four recommendations for Councils and their support teams contained within the main report, covering the following:

- Ensuring robust connectivity
- Providing connectivity for learners', teachers' and visitors' own technology
- Designing safe connectivity models for microcontrollers, modules and platforms
- Addressing barriers to access through minimising multiple sign-ons

4.3 Supporting Technological Environment: Inclusion

Data Education must be inclusively available to all learners, paying particular attention to the following:

- Identifying solutions that combat the poverty-related access to technology
- Looking for innovative solutions to the poverty-related bandwidth gap
- Delivering accessible resources through a universal design for learning

4.4 Supporting Technological Environment: Support Staff

Having staff in place to provide support for digital learning is critical in empowering learners and teachers. This includes:

- Maintaining productive dialogue between university, council, school and technical staff
- Reviewing Internet filter change procedures to ensure they are responsive to the needs of learners and teachers
- Horizon-scanning and professional learning about emerging trends within data education for Council Digital Learning Teams

4.5   Supporting Technological Environment: Software

Ensuring trouble-free access to local and cloud-based software that will support data and digital education is essential. This includes:

- Maintaining up-to-date browsers to access online environments for data education
- Identifying, sharing and opening access to cloud-based learning environments
- Accessing cloud-based storage within Glow, O365 or G-Suite, and University of Edinburgh
- Providing suitable coding platforms across primary and secondary stages
- Addressing technical barriers to learning in Data Education, Cyber Security etc

4.6   Supporting Technological Environment: Hardware

There is an increasing need for access to technology hardware for many aspects of learning, including data and digital education. This includes:

- Regular reviewing of whether hardware is fit for purpose by Councils
- Providing loan-bank access to data education specific hardware by Data Education in Schools
- Addressing one-to-one deployment within individual schools to address any identified gaps in functionality
- Sharing of good practice about maker spaces between University and local authority partners
- Assisting with innovative IOT solutions by University of Edinburgh's Data Technology Service

4.7   Future Research and Evidence Gathering

The City Region partnership should, wherever feasible, contribute towards research and knowledge sharing. In particular, and if resources allow, the research should include:

- Professional dialogue around pedagogy and management of mobile technology in the classroom
- The use of data and digital and its impact on learning and teaching

5   Conclusions

The schools in the Edinburgh City Region will require some adjustments to their digital profile to take full value from the Data Education in Schools programme. These adjustments are achievable in all Education Authorities with the support of key personnel and the provision of a technology lending library of resources.

Critical to the success of the programme in schools will be the close working between the Data Education in Schools team, the Digital Learning Teams and their respective Technical Support Teams. Close working will maximise the likelihood that the digital tools that are available for learning and teaching are appropriate to support the programme.

The University of Edinburgh, through its IOT in Schools programme, will also contribute significantly to the development of Data Education in Schools, giving pupils access to a range of front-edge sensor technology, communication and data processing platforms.

Section 2: Main Report

1   Recommendations in Depth

The technical review focused on four critical areas to support the aspirations of the Data Education in Schools programme and the broader use of digital technologies in Learning and Teaching:

- The views of learners and educators
- Connectivity
- Digital Technology in the Classroom
- Digital Learning and Technical Support

The recommendations relate to specific software, datasets and hardware required for data education, as well as the supportive technological environment to enable data lessons to take place in terms of inclusion, support staff, connectivity, software, hardware.

Each recommendation is directed at schools or specific teams involved in Councils or the University of Edinburgh.

- DES – Data Education in Schools Team, University of Edinburgh
- DLT – Digital Learning Teams, Councils
- DE – Digital Education Team, University of Edinburgh
- TSS – Technical Support Services, Councils

1.1   Access to Specific Software for Data Education

Learners need access to a range of software packages for collecting, analysing and presenting data, including: spreadsheets, point and click data analysis tools, commercial visualisation tools, and programming environments for data science.

In the Broad General Education (BGE), access to a simple spreadsheet package is likely to be most useful, alongside simple point and click analysis tools such as CODAP (see Figure 1). Learners in the Senior Phase (SP), particularly those who choose to study the NPA in Data Science, will additionally benefit from commercially available visualisation tools and specialist programming environments (see Figure 2).
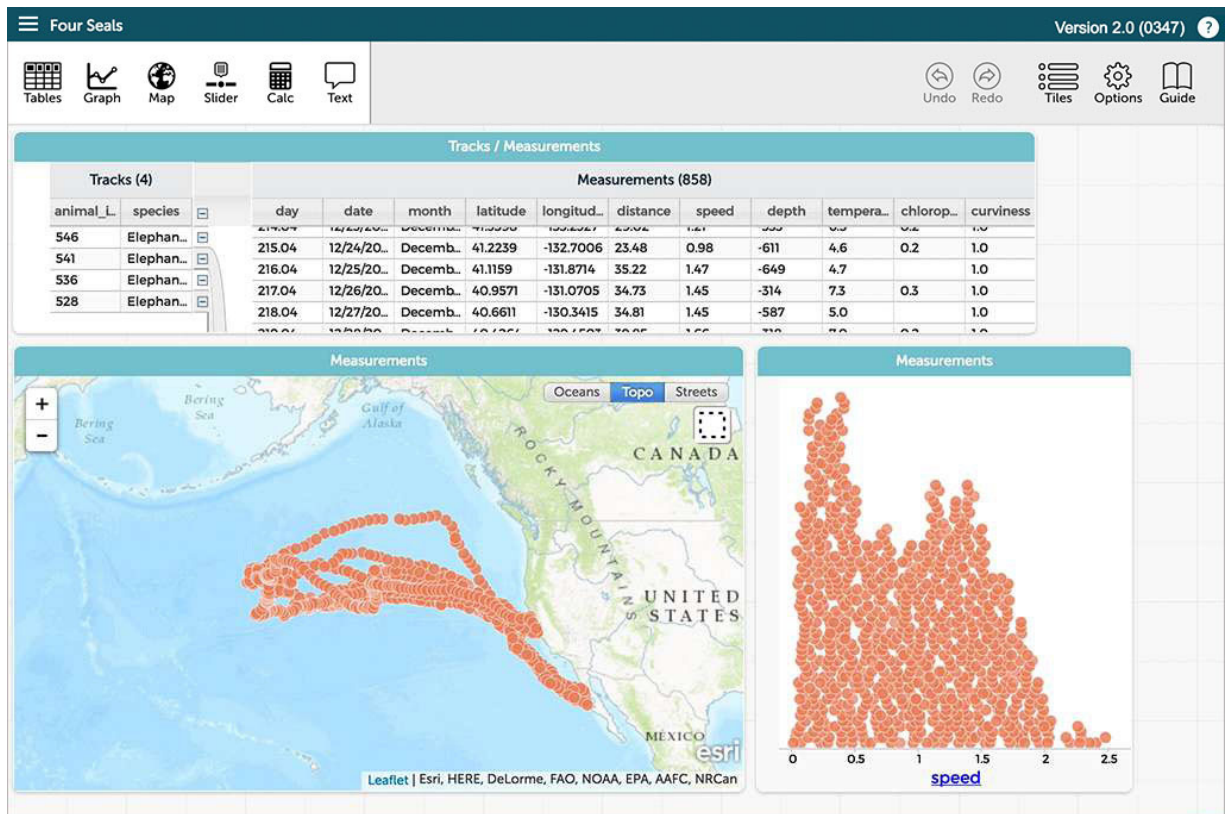
Figure 1. Screenshot of a map visualisation in CODAP
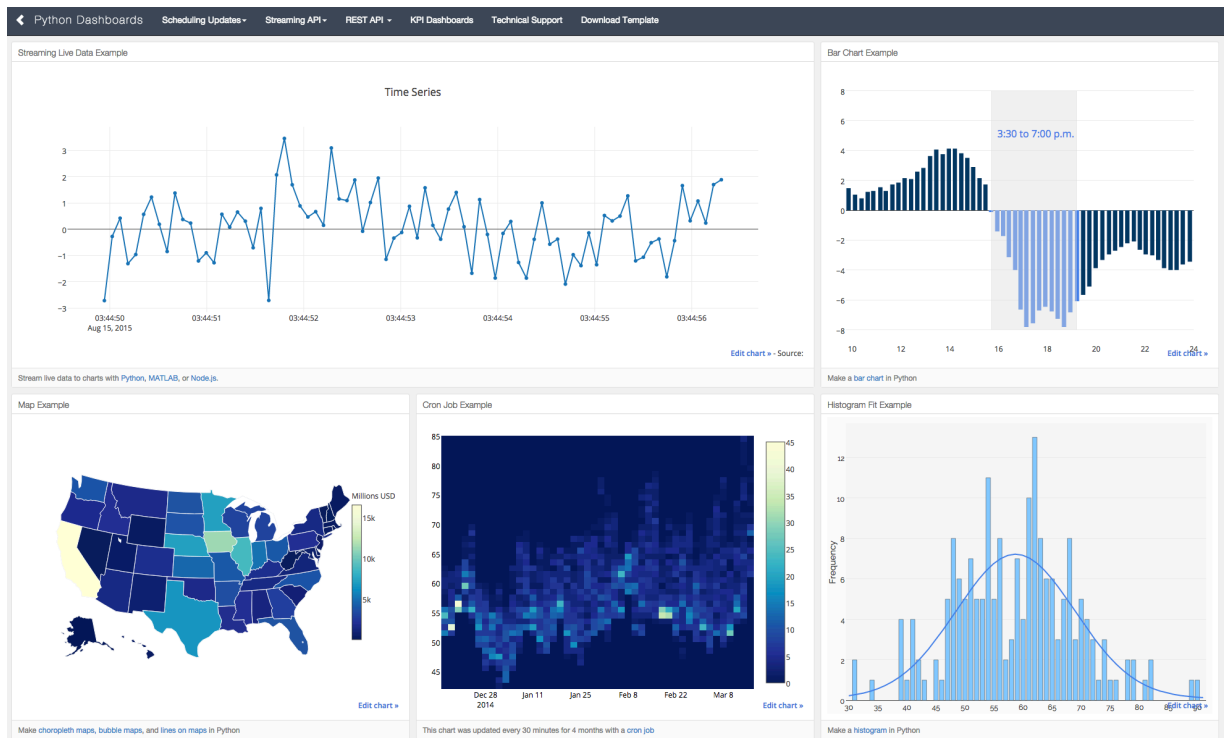
Figure 2. An example data visualisation produced in Plotly with Python

Recommendation (DLT, DES, Schools)

A range of local and online tools should be made available in schools. Learners need access to a variety of software packages for collecting, analysing and presenting data, including: spreadsheets, point and click data analysis tools, commercial visualisation tools, and programming environments for data science. Where these require authentication, Councils should support schools with the necessary security and privacy impact assessments.

Spreadsheet Software

Tool	Link to access	Pros	Cons
Excel	Part of Microsoft suite	Can set up relationships between data tables Wide arrange of graphics options Can write code using VBA	Version control not automatic Cost if not a member of a free programme Need to apply for free access
Google sheets	sheets.google.com	Free for everyone Can publish to the web Can write code using Apps Script	Limited dataset size: 5m cell max – excel is 17bn Limited range of chart options

Table 1 Spreadsheet Software

Point and click data analysis software

Tool	Link to access	Pros	Cons
CODAP	codap.concord.org	Free, open-source and designed for educational purposes Lots of examples Intuitive data exploration Good data manipulation capability, online capability	Data security Version control Not very attractive – designed by academics, not designers
Orange	orange.biolab.si	Very detailed data analysis capability Enables predictive modelling	Need to download, not web-based A small learning curve

Table 2 Point and click data analysis software

Commercial visualisation software

Tool	Link to access	Pros	Cons
Power BI	powerbi.microsoft.com	Good training materials Works well online Intuitive interface	Need to apply for free access Lack of data preparation tools
Tableau	tableau.com	Can write R code Easy to use Integrates well with databases	Need to apply for free access Need to structure data first Version control not easy
Qlik	qlik.com	Attractive and easy to use	Need an account for free access Syntax not very clear
Infogram	infogram.com	Free basic account Simple to use online	Basic package has limited functionality

Table 3 Commercial visualisation software

Programming environments for data science			
Tool	Link to access	Pros	Cons
R	www.r-project.org rstudio.com	Open-source Great interactive development environment (IDE) Packages enable all types of analysis and visualisations Rshiny is used for dashboard and web applications	Steep learning curve Requires some coding capability
Python	Python.org	Open-source Add on packages available to support data science Many different packages for visualisation Plotly is used for interactive plots	Complexity – a full programming language No centralised IDE Steep learning curve Requires some coding capability

Table 4 Programming environment for data science

1.2   Access to Datasets for Data Education

Learning with data will be more meaningful and interesting for learners if it includes analysis of real-world data sets which help them to understand the broader world in which they live. We recommend that learners should have access to open-source data sets for learning and fact-checking websites. Senior phase learners who are studying for the NPA in Data Science will need to download, clean and analyse datasets. The Data Education in Schools website will host datasets and links related to learning materials and tagged with curricular outcomes. Some example data sets with educational applications are illustrated below. However, data education is about encouraging curiosity to find facts, and it's not possible or desirable to decide in advance which facts learners will need. This must be balanced with concerns about child protection online and local authority policies on internet filtering.

Recommendation (DES, DLT, Schools)

There must be a quick process by which teachers and learners can gain access to datasets. They need these to help them find answers to the questions they have proposed as part of the data problem-solving cycle. Typical resources include…

https://www.gapminder.org

A collection of international datasets on health, education, poverty and other social issues.

https://www2.gov.scot/Topics/Statistics

Official Scottish Government statistics

https://www.nrscotland.gov.uk/statistics-and-data

National Records of Scotland – population data, available by geographical region

https://www.ons.gov.uk

Official UK government datasets

http://www.edinburgh.gov.uk/info/20247/edinburgh_by_numbers/1012/edinburgh_by_numbers

Statistics about City of Edinburgh

https://www.eastlothian.gov.uk/downloads/download/12769/east_lothian_by_numbers

Statistics about East Lothian

https://www.westlothian.gov.uk/article/33785/Information-and-Statistics

Statistics about West Lothian

http://www.ourscottishborders.com/invest/facts

Statistics about Scottish Borders

https://informationisbeautiful.net

High-quality data visualisations which present facts about many aspects of society in a compelling way

1.3   Availability of Specific Hardware for Data Education

Advances in Internet of Things (IOT), robotics and environmental sensing technologies give exciting opportunities for learners to collect and analyse local data and contribute this data to citizen science projects. The Data Education in Schools project is working with the Data Technology Team in the University of Edinburgh to provide free Internet of Things kits for schools which enable children to gather and share environmental data safely and securely. The University is also seeking funding for a Technology Lending Library to allow teachers to try out hardware if it is not available from the local authority.

Recommendation (DES, DLT, Schools)
In broad general education, we recommend that learners have access to: • Weather monitoring kits with Chromebook/iPad/Netbooks/other mobile devices • Indoor environmental monitoring kits with Chromebook/iPad/Netbooks/other mobile devices • Outdoor natural world monitoring kits with connectivity or local storage • Science kits with Chromebook/iPad/Netbooks/other mobile devices • An assortment of robot kits, including robotic toys for younger learners • Grow kits and assorted microcontrollers, sensors etc • Class sets of Chromebook/iPad/Netbooks/other mobile devices for plugged sessions • Augmented Reality set when there are good data sets to overlay, perhaps Edinburgh field trips

- Good quality 'autonomous' bots
- Variety of games, display kits
- Alternatives to iPads/Chromebooks/Netbooks for 1to1 schools

Senior phase learners should have access to:

- Weather monitoring kits with Chromebook/iPad/Netbook/other mobile devices
- Indoor environmental monitoring kits with Chromebook/iPad/Netbook/other mobile devices
- Outdoor natural world monitoring kits and LoRaWAN backhauls
- Science kits with Chromebook/iPad/Netbook/other mobile devices
- Alternatives to iPads/Chromebooks/Netbooks for 1to1 schools
- Good quality 'autonomous' bots
- Robotic maker kits, VEX, Lego Technic etc. (straying deep into STEM but with underlying data)
- Robot Playgrounds (arenas with surface, cones, shapes etc.)
- Sensors and assorted parts for extreme autonomous robotics

1.4 Supporting Technological Environment: Connectivity, Coverage and Capacity

To progress with the Data Education in Schools programme, connectivity to WiFi for mobile devices within the classroom has to be robust, with enough coverage to include all learning spaces and sufficient capacity to allow the usual activities around learning and teaching. In the recent past, connectivity has been seen as the greatest enabler but also a significant disabler of learning through digital technology. Learners consulted in the past year in City Region schools indicate that connectivity remains a significant problem. A typical WiFi system has many components that need to be configured and maintained to ensure functional connectivity. Connectivity across all of the City Region's schools is not always robust and learners, especially those with cloud-based file storage, are experiencing difficulty accessing online resources. Learners are also experiencing problems with different identity management systems across learning spaces within the same Council. E.g. Between school and library

Recommendation (TSS, Schools)
Technical Support Services need to ensure that the school WiFi and wired systems are robust and give functional connectivity at all times for learners and teachers. Technical Support Services should pro-actively address connectivity problems. Learners and teachers should raise connectivity issues with the Technical Support Services so that they have full visibility of developing issues.
Continuity of connectivity between the school, local library and other learning spaces also needs to be significantly improved in some Councils.

1.4.1 Connectivity for Learners' and Teachers' own devices

Some secondary schools have embraced the use of learners' own technology, and others have also supported teachers to bring in their technology. This has some advantages as users are usually most comfortable with their own configured technology. With classwork around computing and data, learners or teachers own technology may be configured to a level of sophistication that is not possible with a generic school device. However, classroom management can be a challenge in respect of resources and discipline, and not all teachers feel comfortable with this arrangement.

Recommendation (DLT, TSS, DE)
Digital Learning Teams, Technical Support Services and the Digital Education Research Centre, with their expertise and experience of connecting student and academics' technology, should collaborate to inform the debate around learners' and teachers' devices in school. Digital Education, University of Edinburgh will run a seminar on the topic to share practice and inform progress.

1.4.2 Connectivity to WiFi for raspberry pi, Arduino, micro:bit derived products

The Curricular Framework for Data Education in Schools will make repeated reference to the use of microcontrollers, modules and platforms to develop coding, robotics and other activities. Most of the activities will not require connectivity to the school's network and will make use of floating WiFi networks and Bluetooth. However, occasionally, there may be the need to connect to school's WiFi, especially where the project requires the collection of internet located data.

Recommendation (DES, TSS, DLT)
The Data Education in Schools Team will work with Council Technical Support Services and Digital Learning Teams to design safe connectivity models for raspberry pi, Arduino, Micro:bit and other modules used within the curricular framework.

1.4.3 Eduroam and Single-Sign-On

Single-Sign-On, although often difficult to achieve technically, is a definite advantage to learners and teachers. Some services to mobile devices, particularly filtering, have time-outs which can be disruptive to learning. As the Data Education in Schools programme progresses and other partnerships develop around learners and teachers with further and higher education, there will be the need for increased authentication across establishments.

Recommendation (TSS, DLT)

The use of Eduroam or similar roaming services would simplify the logging in process for learners and teachers between establishments outwith their Council area. Research is currently underway in one secondary school to see if Eduroam is a viable option. Two Councils have already achieved Single-Sign-On between the local and Glow directories. All Technical Support Services and Digital Learning Teams should share good practice across the City Region.

1.5 Supporting Technological Environment: Inclusion

1.5.1 Closing the poverty-related technology gap

Increases in technology-related employment in the South East Scotland area through the Data Driven Innovation programme has the potential to improve the poverty gap. Every effort must be made to ensure that the poverty-related attainment gap is not fuelled by a lack of technology available to learners that are challenged by poverty.

Recommendation (DES, DLT, DE)

The Data Education in Schools team will work with Digital Learning Teams across Council areas to identify viable solutions to the poverty-related technology gap and share these across the City Region schools. The Digital Education team will convene a professional dialogue around poverty, attainment and technology.

1.5.2 Access to connectivity for learners with bandwidth poverty

Many learners use their mobile phones with hot spots to support their learning, as a device to use within the classroom, between the classroom and home, or in the home. The challenge exists for many youngsters when they have a device, and their mobile contract contains little or no data. Solving this challenge may allow us to take a step forward on the poverty-related attainment gap.

Recommendation (DLT, DES)

Some Digital Learning Teams are already looking for solutions to the issue of bandwidth poverty, and the Data Education in Schools Team will take every opportunity to share practice and further raise the profile of the problem with Education Scotland and Scottish Government.

1.5.3 ASN and Assistive Technology

Legislation and Getting it Right for Every Child demands that we use every means possible to make the curriculum accessible to all learners. The Data Education in Schools programme will not be available to all learners unless technology can support accessibility. CALL Scotland, based in Moray House School of Education and Sport provides support for accessibility and assistive technology throughout Scotland. It also posts regularly updated advice on its website at www.callscotland.org.uk

Recommendation (CALL, TSS, DES)
Schools should take full advantage of the free resources and sign posting available from CALL Scotland to support learners with additional support needs and their teachers. Digital Learning Teams and Technical Support Services should adopt the technical advice offered by CALL Scotland, installing recommended software and enhancing support for learners. The Data Education in Schools team should ensure that all resources are compatible with a Universal Design for Learning approach.

1.6 Supporting Technological Environment: Support Staff

1.6.1 The ability of support service to install software

Within the Data Education in Schools Curriculum Framework, resources will be recommended, developed or made available that require installation of software on client devices in schools. Installation of software should not be a regular occurrence and is likely to be for a small number of devices in each school, most probably sector specific.

Recommendation (DES, DLT, TSS)
A dialogue should be opened between the Data Education in Schools team, Digital Learning Teams and the Technical Support Services so that emerging applications are available for testing as soon as considered for inclusion in learning materials relating to the data education curriculum framework. The University of Edinburgh will take feedback on security and other concerns from Council Technical Support Services and adjust their materials accordingly.

1.6.2   Filter and firewall changes to allow access to particular cloud content

Some learners in City Region schools still have difficulty accessing content online, despite all Education Authorities implementing a fast response to filter related requests. To maximise the use of cloud resources, it is essential to adjust the filters and make appropriate web content available. Sometimes the content cannot be delivered through http and https and it may be necessary to make firewall changes, although these will be kept to an absolute minimum.

Recommendation (DES, TSS, DLT)

Digital Learning Teams should continue to encourage teachers and learners to report difficulties in accessing internet content so that it may be referred and resolved. The Data Education in Schools Team will share a list of domains that will be used as part of their Curriculum Framework. Schools that have identified suitable resources can add to that list so that others throughout the City Region may also consider using them.

Where a resource requires changes to the firewall, this will be tested by individual Council Technical Support Services before being considered for inclusion in the Curriculum Framework. Any such changes will have a lead time over three months once tests are completed. Digital Learning Teams will be kept appraised of progress.

1.6.3   Technical Support in Schools

Schools often need technical support for many aspects of digital learning. The support needs to be delivered timeously and to be suitable for learning and teaching. Some schools have had their locally based technician withdrawn in favour of a centrally deployed team. Teachers in City Region schools have commented that there is a lack of support for digital technology in schools.

Schools that have a technician on the premises appear to find innovation with new technology much more accessible than those without, but further research is required to draw conclusions. The use of learning technologists in further and higher education is commonplace, but schools have yet to experience how that type of role can support learning and teaching. Some pilot work is underway in one Education Authority, and this will be reported to the City Region Education Authorities as soon as practicable.

Recommendation (DES, DE, Schools)

The Data Education in Schools Team, supported by Digital Education, will inform Digital Learning Teams and Councils of any emerging trends in the support for digital learning in schools. Where

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practicable, it will also help Digital Learning Teams to evaluate their front-line technical support concerning the Data Education in Schools programme.

1.6.4   Digital Learning Support and Professional Learning

The use of digital tools to support learning and teaching requires specialist support, and it is rarely possible to deliver all of this in-house within each school. All Councils within the Edinburgh City Region have central staff with a remit to support Digital Learning. These staff need support from external agencies to be able to cover the wide range of professional learning that is required.

Recommendation (DES, DE, Schools)

The Data Education in Schools Team, will support Digital Learning Teams to deliver professional learning for the Curriculum Framework. It will also help to signpost professional learning to support the broader use of digital across the curriculum.

1.7   Supporting Technological Environment: Software

1.7.1   Browsers and browser versions

The use of internet browsers will become increasingly important to the Data Education in Schools programme and the broader curriculum as more applications are cloud based. All City Region schools have a Microsoft browser, either Edge or Internet Explorer, and Chrome. Some also have a third option of Firefox on request. To make the use of browsers trouble-free, it is essential that these are kept reasonably up-to-date and that developers of web-based resources are aware of the version capabilities across most schools. It should be recognised, however, that many pupils, staff and schools have devices that are not centrally managed and therefore at various levels of update.

Recommendation (TSS, DLT, DES)

The browser types, versions, add-ins and extensions from centrally managed devices in each Education Authority should be shared with the Data Education in Schools team, at least once per school session. Future roadmaps where available should also be shared, especially large-scale updates or changes that may affect current applications.

The Data Education in Schools team will collate information received from Education Authorities and share as appropriate within the University and with partners developing applications or

materials for the data education curriculum framework. It will also advise Education Authorities of any browser-based roadmaps from the products identified within the planned materials and attempt to gather development roadmaps for products under consideration.

1.7.2   Cloud-Based Applications

Some cloud-based applications will be identified for use as part of the Data Education in Schools learning materials. Every effort will be taken to ensure that these will run satisfactorily within the school environment.

Recommendation (DES, DLT, Schools)

The Data Education in Schools team will identify, collate and circulate a list of cloud-based applications that will support the learning outcomes in the data education curriculum framework. It will also look to schools and Digital Learning Teams to share their expertise with resources that they have identified and used successfully in the classroom. An open dialogue between Digital Learning Teams and the Data Education in Schools team through their existing collaborative forum will reduce the likelihood of issues developing over access to cloud-based applications.

1.7.3   Cloud Hosting

Until there is a common storage platform that can be accessed by every pupil and teacher throughout the Edinburgh City Region, resources will be stored centrally in a University of Edinburgh web-enabled file store. Where authentication is required, this will be delivered by the best means possible for each Council area. In Fife, West Lothian, Midlothian and Scottish Borders, that is likely to be within Glow. In the City of Edinburgh, it will initially be within their O365 tenancy and for East Lothian, within their Google Drive.

Recommendation (DES, DLT)

Resources including data sets made available as part of the Data Education in Schools programme should be initially published within University of Edinburgh webspace and, if authentication is required, replicated within Glow, CoE O365 and EL Google Drive. As necessary, publications will be moved to the Glow environment when learners and teachers throughout the Edinburgh City Region have regular access. Support will be required from digital learning teams to upload the materials to the appropriate online space.

1.7.4   Coding platforms

Cloud-based coding platforms have many advantages for school-based learners over locally deployed applications. The main drawback, however, is that there has to be authenticated access, hence sharing of directory credentials or personal identities. For some of the most innovative solutions, this is likely to be a problem around GDPR. There are ways to minimise the risk, but these need to be addressed within a full Data Privacy Impact Assessment and Network Security Assessment in each Council area.

Recommendation (DES)
The Data Education in Schools team should investigate coding environments and associated identity management systems to see if a suitable platform can be offered across all City Region schools and advise Digital Learning Teams on DPIA where appropriate.

1.7.5   Coping with technically demanding courses e.g. NPA Data Science, NPA Cyber Security

Some National Progression Awards require learners to work with digital technology that can be a challenge to school networks. These awards are beneficial to learners, in particular those that are looking at employment or further study destinations within data and digital. The University of Edinburgh, with their contacts across the City Region Education Authorities and schools, are in an excellent position to identify technical barriers to learning and propose solutions.

Recommendation (DES, DLT, Schools)
The Data Education in Schools team will continue to identify technical barriers to learning, in particular involving NPA in Data Science and Cyber Security and share possible solutions. Research is already underway in some City Region schools, and this will be shared at an appropriate time.

1.8 Supporting Technological Environment: Hardware

1.8.1   Provision of Digital Technology

One local authority has shared the results of a survey covering digital innovation and digital literacy in Quality Indicator 3.3, Increasing Creativity and Employability, from How Good is Our School 4. That data, in addition to feedback given during the recent University of Edinburgh Data Town events, indicates that there is an appetite from learners and teachers to have more access to digital technology in schools.

Recommendation (DES, Councils, Scottish Government)

Councils should continually review whether learners and teachers have sufficient access to digital technology to meet their needs. The Data Education in Schools Team will continue to make senior leadership teams in Councils and the Scottish Government aware of the need for continued investment in digital technology hardware in schools.

1.8.2 Technology Lending Library

It is not cost-effective for all schools to have the full range of equipment to cover all aspects of the Data Education in Schools Curriculum Framework and many other aspects of digital learning. The use of central loan-banks of equipment has been successful across many Education Authorities.

Recommendation (DES, Schools, DLT)

The Data Education in Schools team will look for funding to create a loan bank of equipment that can be deployed into schools for short periods. The equipment will come alongside support materials to help staff integrate the technology into learning and teaching. Professional learning opportunities will also be available to support teachers and, should funding become available, those borrowing from the loan-bank will also have access to technology experts. Digital Learning Teams should investigate whether it is possible to locate loan-bank equipment in Knowledge Sharing Schools or central locations within each Council area.

1.8.3 Specific support for schools with one-to-one devices

Scottish Borders are rolling out a large number of iPads which will mainly be used by individual pupils. Some other schools are also looking 1to1 programmes involving iPads and Chromebooks. It is therefore essential that at least some resources identified within the Data Education in Schools programme are capable of running in Apple IOS and Chrome OS or workarounds are identified. The workaround may be alternative resources or the availability of a Technology Lending Library of other devices.

Recommendation (DLT, DES)

Councils should work with the University of Edinburgh to identify and support possible alternatives to resources identified as part of the data education materials.

The Data Education in Schools team, within available resources, will seek to deploy loan bank equipment within each Council area, to ensure accessibility of the Curriculum Framework. The Data Education in Schools team will work closely with each Digital Learning Team to devise the support required in each Council area.

1.8.4　Maker spaces

Maker activities will be integral to the Data Education in Schools Curriculum Framework. Although maker activities are commonplace within City Region schools, maker spaces are not. Most activities involving design and build of robotic and other data and digital projects, include significant effort on the part of the teacher to collect and make available the necessary kit. Organising a maker space or corner, removes some of the associated work and allows the teacher to use the area throughout the week. The availability of a loan bank of equipment with associated curricular and technical advice will also provide valuable support to schools.

Recommendation (DES)

The Data Education in Schools team will share good practice around maker spaces as these develop in schools and other settings. It will also look to develop an equipment loan bank, capable of supporting a variety of topics around data and digital, alongside expert advice.

1.8.5　IOT (Internet of Things)

A pilot study is underway to test a Long Range Wide Area Network (LoRaWAN) across the City of Edinburgh and Midlothian. Should this be successful, the plan is to cover the entire Edinburgh City Region. The study is primarily to connect IOT sensors, transmitting small data packets over vast distances. LoRa is an ideal backbone for schools to use for a variety of projects involving sensors and microcontrollers. Schools will have access to a LoRa Gateway, sensors and microcontrollers to set up their projects. Eg Climate Monitoring

Recommendation (DTS, DLT, DES, Schools)

The Data Technology Service will complete the pilot work and circulate design documentation to support Digital Learning Teams and their Technical Support Services in connecting LoRa Gateways to the schools'

> networks. IOT kits will be available to schools, alongside learning and teaching resources support to integrate this new technology into learning around STEM.

1.8.6 Mobile phone use within the classroom

Mobile phone use within the classroom is sporadic across many schools. Some schools have decided to ban the use of mobiles phones, and others encourage it. The teaching profession needs to open a dialogue on mobile phone use within the classroom to look at whether there is an achievable benefit or a challenge to classroom discipline and management.

Recommendation (DE, Schools)

The Digital Education Research Centre in Moray House School of Education and Sport will support professional dialogue on the use of personal mobile devices within school education, allowing teachers and academics to share their expertise and learn lessons from studies across the world. Their findings will be disseminated across the Edinburgh City Region schools.

1.9 Future research and evidence gathering

1.9.1 Evaluation of the attitude to the impact of digital on learning

All partners recognise the value gathering the views of learners, teachers and parents in understanding attitudes to digital learning. An Edinburgh City Region Education Authority has conducted extensive research with its stakeholders on Digital Learning Strategy, and that is now shaping their service going forward. The University of Edinburgh has also gathered baseline evidence on Data Education to inform its programme.

Recommendation (DES, DE, DLT, Schools)

Should funding become available, the Data Education in Schools team will collaborate with Digital Education, Digital Learning Teams and Schools to conduct further research across other Education Authorities, gathering more comprehensive sets of baseline evidence. After that, further research could be targeted to particular influences on the use of data and digital education.

2 The Views of Learners and Educators

2.1 What young people want to learn about data

The Data Education in Schools team consulted with more than 180 primary and secondary school children from across the City Region about their views on data education at a series of "Data Town" events held in Edinburgh, Fife and Scottish Borders. We asked what they would like to learn about, and what they would need to help them learn. The participants were surprised by how much there was to learn about data and curious to find out more, particularly on the topics of robotics, sensors, hacking, and data sharing and privacy. When asked what they would need to help them to learn about data, the young people identified resources including particularly "experts" or "specialists"; personal research, school-based learning with teachers and technology. Their comments included:

"I would like to learn more about how sensors impact on everyday life"

"I was surprised that data is sold without permission"

"I would like to learn more about how data is protected"

"I would like to learn more about data laws"

"I was surprised that data could help with climate change"

The Data Education in Schools team is taking forward these ideas when planning the development of new resources. It will also establish a Young Person's Advisory Group to ensure that learners' views are taken into account during the eight-year programme.

2.2 Learners' views about digital learning

2.2.1 Experiences and attitudes regarding digital learning

The young people who attended the Data Town event in Edinburgh were also consulted about their views on digital learning at school (78 pupils).

Respondents were asked to indicate how often they used computers or tablets to carry out various learning tasks. Figure 3 and Table 5 show the differences between primary and secondary learners' views. Technology is used most frequently for fact-checking and topic work in both primary and secondary schools. It is more commonly used in primary school for both literacy and number work than in secondary schools. Around one-third of secondary school pupils never or hardly ever use technology for literacy or number work. This

contrasts to a 2016 national survey[1] in which 24% of S2 pupils seldom or never used technology for literacy and 41% seldom or never used it for number work. Of course, there is no "correct" proportion of time for which learning should be supported by technology because this is dependent on the task and the professional judgement of the teacher. However, it would be unfortunate if a lack of resources prevented learners from using technology on appropriate tasks to prepare them for a world of work which is mostly digital.

A particularly relevant difference for data education was on the frequency to which students use computers, tablets, etc to create graphs, tables or charts. Primary students do not use technology for this task very often compared to secondary students who use it more frequently.
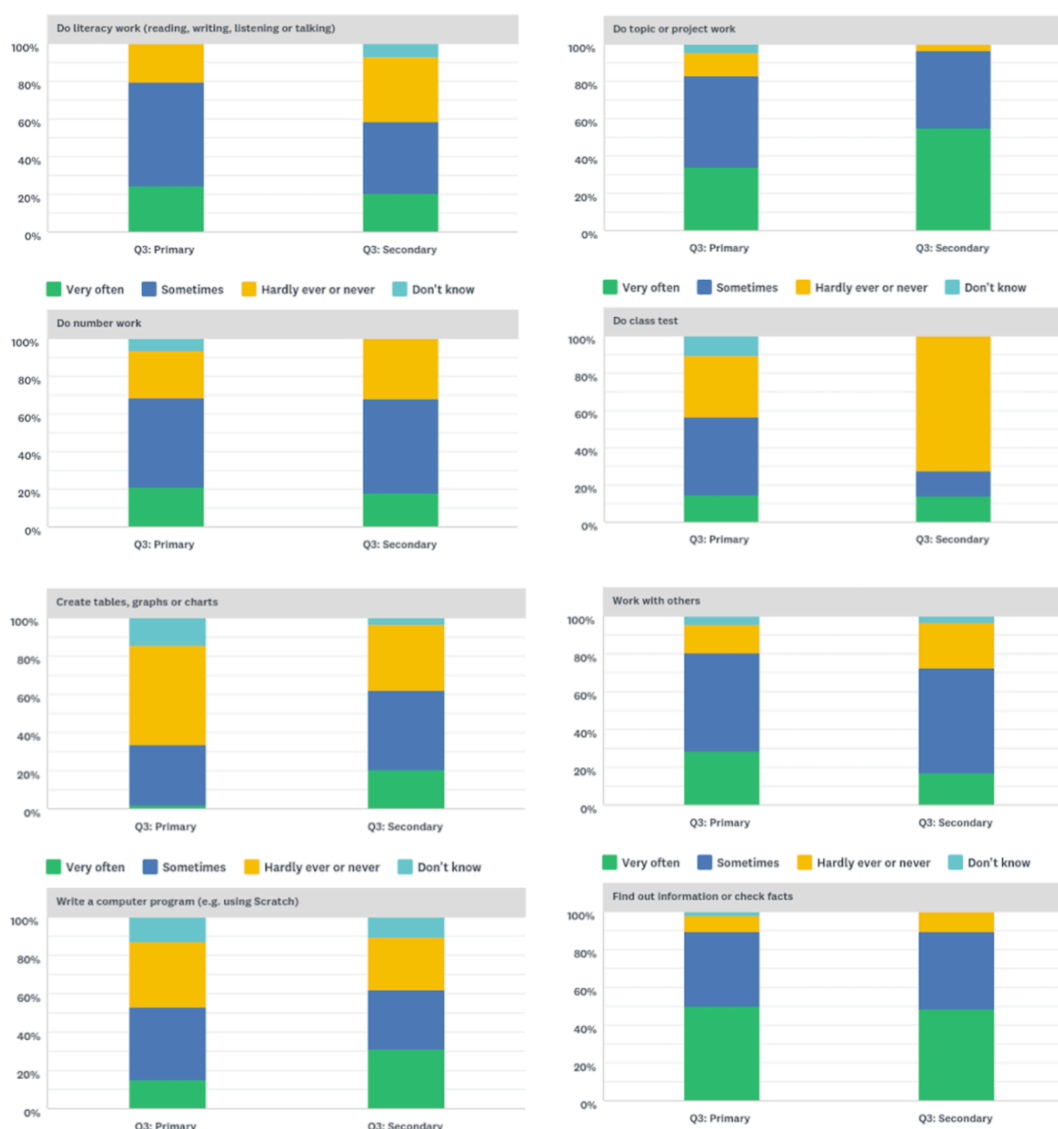
Figure 3. Frequency of digital learning for different tasks.

[1] https://www2.gov.scot/Topics/Statistics/Browse/School-Education/SSLN

Do literacy work (reading, writing, listening or talking)

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	24.49% 12	55.10% 27	20.41% 10	0.00% 0	62.82% 49
Q3: Secondary	20.69% 6	37.93% 11	34.48% 10	6.90% 2	37.18% 29

Do number work

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	20.83% 10	47.92% 23	25.00% 12	6.25% 3	61.54% 48
Q3: Secondary	17.86% 5	50.00% 14	32.14% 9	0.00% 0	35.90% 28

Do topic or project work

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	34.04% 16	48.94% 23	12.77% 6	4.26% 2	60.26% 47
Q3: Secondary	55.17% 16	41.38% 12	3.45% 1	0.00% 0	37.18% 29

Do class test

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	14.58% 7	41.67% 20	33.33% 16	10.42% 5	61.54% 48
Q3: Secondary	13.79% 4	13.79% 4	72.41% 21	0.00% 0	37.18% 29

Work with others

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	28.26% 13	52.17% 24	15.22% 7	4.35% 2	58.97% 46
Q3: Secondary	17.24% 5	55.17% 16	24.14% 7	3.45% 1	37.18% 29

Find out information or check facts

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	50.00% 24	39.58% 19	8.33% 4	2.08% 1	61.54% 48
Q3: Secondary	48.28% 14	41.38% 12	10.34% 3	0.00% 0	37.18% 29

Create tables, graphs or charts

	VERY OFTEN	SOMETIMES	HARDLY EVER OR NEVER	DON'T KNOW	TOTAL
Q3: Primary	2.08% 1	31.25% 15	52.08% 25	14.58% 7	61.54% 48
Q3: Secondary	20.69% 6	41.38% 12	34.48% 10	3.45% 1	37.18% 29

Table 5. Frequency of digital learning for different tasks.

In response to question "If you could change how often technology is used for learning at your school, what would you prefer", the number of secondary school participants chose approximately equal between "I'd use technology for learning more often" and " I'd keep it the same" while 56% of the primary students chose "I'd use technology for learning more often" (see Figure 4)

Q7 If you could change how often technology is used for learning at your school, what would you prefer

Answered: 78   Skipped: 0
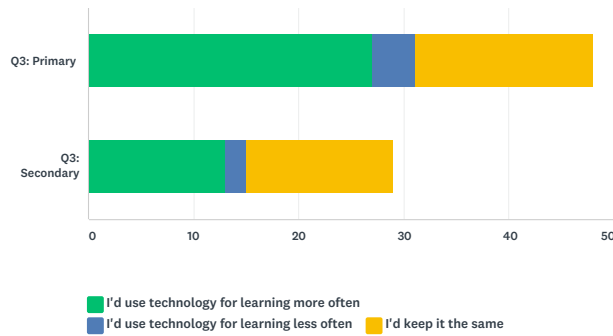
- ■ I'd use technology for learning more often
- ■ I'd use technology for learning less often
- ■ I'd keep it the same

	I'D USE TECHNOLOGY FOR LEARNING MORE OFTEN	I'D USE TECHNOLOGY FOR LEARNING LESS OFTEN	I'D KEEP IT THE SAME	TOTAL
Q3: Primary	56.25% 27	8.33% 4	35.42% 17	61.54% 48
Q3: Secondary	44.83% 13	6.90% 2	48.28% 14	37.18% 29
Total Respondents	40	6	31	78

Figure 4. Preferences about using technology more or less in the classroom

Fifty-four comments were given regarding this question. Thirty-one comments gave a justification for answering "I'd use technology for learning more often". The majority of these comments were about technology being more enjoyable and fun, as well as easier to use and learn. A few examples are:

"Because it is way easier and fun"

"It is fun and easy to use. it will make everyone wanting to come to school more"

"it's easier and faster this also means we save paper"

"Because learning can be more interesting and fun"

The main justification of the 18 respondents who replied "I'd keep it the same" was balance.

A few examples are:

"I enjoy doing written work as well as going on the computers"

"I think we should keep it the same because it is balanced"

"For balance"

Learners were also consulted on their confidence in using digital tools for a variety of learning tasks related to the data problem-solving cycle (Table 6). Most of the learners at both primary and secondary school were very confident about using technology to find facts, at 59% and 79% for primary and secondary school learners, respectively. However, this is considerably lower than in the 2016 national survey in which over 90% of learners of comparable age were very confident. For the task of making graphs, only 16% of primary learners were very confident, compared to 75% of the national sample, and at secondary level 34% were very confident, compared to 78% in the national sample. This result is unsurprising, given the high proportions of learners in the Data Town sample who hardly or never had the opportunity to use technology for this task. When asked about confidence in presentation skills, 47% of the primary learners and 83% of the secondary learners in the Data Town sample were very confident, again both lower than the national survey which reported that 88% and 90% of learners of comparable age groups were very confident.

Lastly, because programming is a relevant skill for data science, we asked about confidence in writing a computer program. The majority of the learners were very confident or confident, with primary school children more confident than their secondary peers. This is an encouraging finding because of the importance of this digital skill to the general economy, and for the Data Education in Schools programme in particular. This question was not asked in the 2016 national survey, so it is not possible to compare this local sample to the national picture.

There are obvious caveats to interpreting this data because the sample is relatively small and is biased in the sense that schools who chose to attend the Data Town event might have done so because the school values digital technology. Schools may also have selected children with an aptitude or preference for technology subjects to attend. This selection raises some doubts that the high confidence in programming would be found in other schools in the region. However, the lower confidence in comparison to the national findings with respect to using digital tools for tasks in the data problem-solving cycle is potentially concerning.
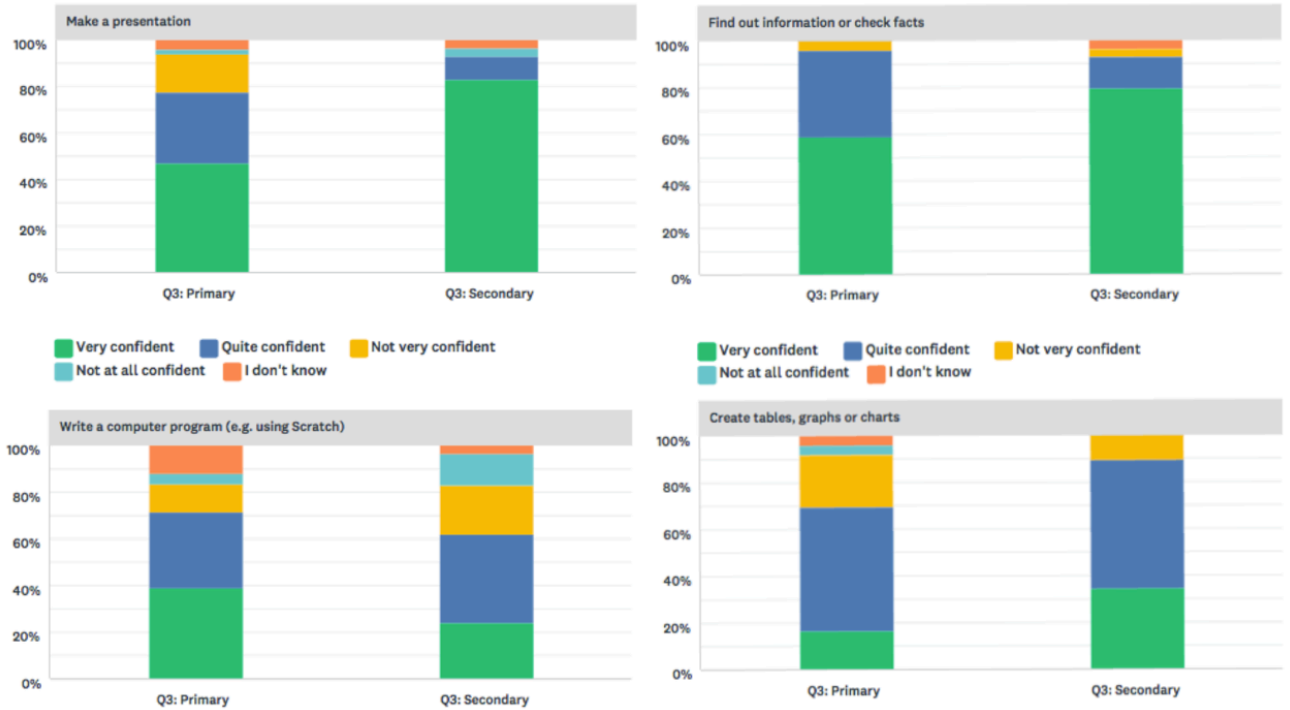
Figure 5. Learners' confidence in using digital tools for various tasks

Find out information or check facts

	VERY CONFIDENT	QUITE CONFIDENT	NOT VERY CONFIDENT	NOT AT ALL CONFIDENT	I DON'T KNOW	TOTAL
Q3: Primary	59.18% 29	36.73% 18	4.08% 2	0.00% 0	0.00% 0	62.82% 49
Q3: Secondary	79.31% 23	13.79% 4	3.45% 1	0.00% 0	3.45% 1	37.18% 29

Create tables, graphs or charts

	VERY CONFIDENT	QUITE CONFIDENT	NOT VERY CONFIDENT	NOT AT ALL CONFIDENT	I DON'T KNOW	TOTAL
Q3: Primary	16.33% 8	53.06% 26	22.45% 11	4.08% 2	4.08% 2	62.82% 49
Q3: Secondary	34.48% 10	55.17% 16	10.34% 3	0.00% 0	0.00% 0	37.18% 29

Make a presentation

	VERY CONFIDENT	QUITE CONFIDENT	NOT VERY CONFIDENT	NOT AT ALL CONFIDENT	I DON'T KNOW	TOTAL
Q3: Primary	46.94% 23	30.61% 15	16.33% 8	2.04% 1	4.08% 2	62.82% 49
Q3: Secondary	82.76% 24	10.34% 3	0.00% 0	3.45% 1	3.45% 1	37.18% 29

Write a computer program (e.g. using Scratch)

	VERY CONFIDENT	QUITE CONFIDENT	NOT VERY CONFIDENT	NOT AT ALL CONFIDENT	I DON'T KNOW	TOTAL
Q3: Primary	38.78% 19	32.65% 16	12.24% 6	4.08% 2	12.24% 6	62.82% 49
Q3: Secondary	24.14% 7	37.93% 11	20.69% 6	13.79% 4	3.45% 1	37.18% 29

Table 6 Learners' confidence in using digital tools

2.2.2 Hardware

The Edinburgh Data Town respondents were asked to select the type of technology they use at their school. "ipads or other tablets" had most of the answers from with 86% followed by "Laptops, netbooks or Chromebooks in the class" and "Computers in a computer room" with 65%, "Phones" with 35 %, "Robots and similar technologies" with 15%, "Arduinos, Raspberry PIs, sensors and other bits of hardware" with 5 % and 1% of the respondents who replied that they don't use technology at all.

Figure 6 shows the breakdown of technology usage by primary and secondary pupils. It illustrates some challenges for the Data Education in Schools programme because while tablets were common in primary schools, only 44% of the primary pupils in this sample had access to computer rooms, and only 53% had laptops or similar devices. Robots and hardware such as Arduinos were more common in primary schools than secondary schools, but still very uncommon.

Q4 Please tick which technology (if any) you use at school

Answered: 78   Skipped: 0
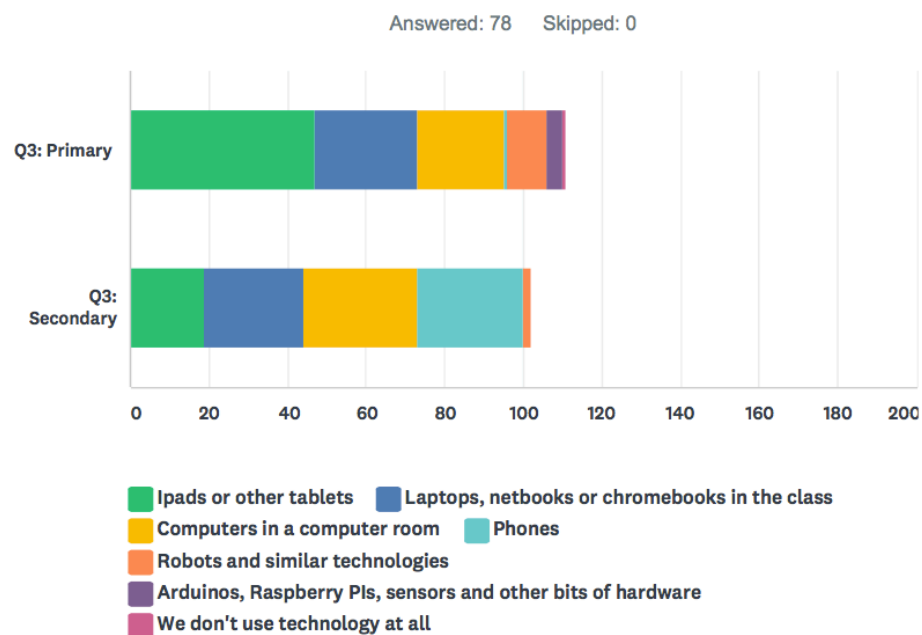
	IPADS OR OTHER TABLETS	LAPTOPS, NETBOOKS OR CHROMEBOOKS IN THE CLASS	COMPUTERS IN A COMPUTER ROOM	PHONES	ROBOTS AND SIMILAR TECHNOLOGIES	ARDUINOS, RASPBERRY PIS, SENSORS AND OTHER BITS OF HARDWARE	WE DON'T USE TECHNOLOGY AT ALL	TOTAL
Q3: Primary	95.92% 47	53.06% 26	44.90% 22	2.04% 1	20.41% 10	8.16% 4	2.04% 1	142.31% 111
Q3: Secondary	65.52% 19	86.21% 25	100.00% 29	93.10% 27	6.90% 2	0.00% 0	0.00% 0	130.77% 102
Total Respondents	66	51	51	28	12	4	1	78

Figure 6. Technology used at school by Data Town participants in Edinburgh.

The participants were also asked the question: "if you had the job of deciding what technology to buy to help people learn at your school, what would you buy?" (Figure 7). The primary school children would invest in more tablets (63%) and laptops/netbooks/Chromebooks (57%). The secondary school learners would choose to buy more laptops/netbooks/Chromebooks (60%), more tablets (32%) and more computers in a classroom (32%). The primary school learners did not particularly favour investing in computers in a computer room, but were keen on acquiring robots and similar technologies (40%). Only a modest number of primary and secondary participants expressed a wish to buy Arduino and related hardware, but this is not surprising given that a low proportion of them had experienced using them before, and it is likely that many had never heard of them (one answer specifically stated this).

Q8 If you had the job of deciding what technology to buy to help people learn at your school, what would you buy?

Answered: 77   Skipped: 1
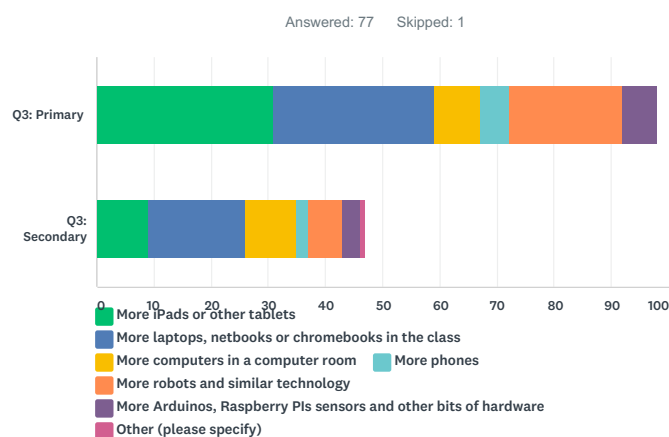
	MORE IPADS OR OTHER TABLETS	MORE LAPTOPS, NETBOOKS OR CHROMEBOOKS IN THE CLASS	MORE COMPUTERS IN A COMPUTER ROOM	MORE PHONES	MORE ROBOTS AND SIMILAR TECHNOLOGY	MORE ARDUINOS, RASPBERRY PIS SENSORS AND OTHER BITS OF HARDWARE	OTHER (PLEASE SPECIFY)	TOTAL
Q3: Primary	63.27% 31	57.14% 28	16.33% 8	10.20% 5	40.82% 20	12.24% 6	0.00% 0	127.27% 98
Q3: Secondary	32.14% 9	60.71% 17	32.14% 9	7.14% 2	21.43% 6	10.71% 3	3.57% 1	61.04% 47
Total Respondents	40	45	17	7	26	9	1	77

Figure 7. Young people's views about what technology to buy for their school

Fifty-two comments were given to explain the participants' reasons for suggesting an investment in particular technologies. The majority of the comments were on the practicality and ease of use of devices like tablets and laptops as well as interest in technologies like robots and Arduino like hardware. Feedback relating to the lack of availability of up to date technology in schools were prevalent. Examples of the reasons are:

> "don't have enough ipads and some of them don't work"

> "laptops are very useful"

"Ipad cause they are touch screen and reasonably simple to use for most age groups and they are small enough to lift"

"computers in a computer room will help familiarise students with computers when they are older"

"it would be nice to have robots to experience different technology"

"I think robot/AI would be useful in teaching students about coding, robot etc."

"Robots and Raspberry pi's are interesting pieces of technology which haven't been looked at at all in school"

Overall, only 9 participants replied to the question "Is there anything else you'd like to tell us about how to improve technology for learning at school?". Most comments were about resources, such as technology which needs to be upgraded (wifi, smartboards and apps) while two commented that there is a need for more resources for people with dyslexia.

2.3 A snapshot of learners' and educators' views

In June 2019, a local authority within the City Region conducted an online survey of digital leaders, teachers and learners' views of school-based digital learning services. The qualitative free-text comments in this survey were analysed by a postdoctoral student at the University of Edinburgh to identify themes which would be generally relevant to digital learning provision across the region. 608 comments were considered. Of these, 41 responses were given by Leaders, 341 were given by Learners, and 227 were given by Teachers. The frequency of comments categorised by various themes is shown in Figure 8. Almost 500 of the replies included comments about the quality of the internet and/or the lack of or outdated equipment and/or the need for staff training

Theme frequency by survey respondent category

Theme	Learner	Teacher	Leader
various (ASN, learning difficulties, GLOW)	0	3	4
restrictions and limitations (social media, app instalation etc.)	34	19	0
management, policies and support	5	47	10
internet and connectivity	156	54	10
resources (hardware and equipment)	85	129	21
pupil skill development (programming, movies, animation, games, robots)	81	15	0
staff training	9	72	22

Figure 8. Themes from free-text comments in local authority survey about digital learning

The reliability and speed of the internet connection to classes were of concern to leaders, teachers and learners, as summed up by this comment from a learner: "wifi is slow and not very reliable, our teacher is always getting the IT man in to fix the internet but then it is still slow". Some teachers were particularly frustrated with the time it takes to log onto network resources: "Connection to the network and time taken to login needs improvement. When a whole class tries to log in to Chromebooks at the same time, the network grinds to a halt, and it sometimes takes pupils 20 minutes to get logged in, taking away from their learning time."

Teachers raised concerns about reduced availability of up-to-date equipment, and about the time it takes to get equipment repaired, as this comment illustrates: "Chrome books do not cover a full class, and there are not enough to go around. More computers in classes, more specialist software for students with ASN are required. There needs to be more investment in tech for students. Computer rooms need to be accessible to all and easily booked". This point of view is consistent with views expressed by learners such as "we would end up having to share with our classmates, while I am comfortable sharing with any of my classmates it can be frustrating as we sometimes don't get to do what we would have liked to". Another learner wrote, "I do believe that using more technology in my learning would make it more interesting and better technology would make it easier and less frustrating to use consistently". Some teachers were doubtful about Bring-Your-Own-Device policies (which can mitigate lack of hardware in some circumstances), because they regarded it as inequitable.

Learners and teachers both reported frustration about content restrictions and limitations. The pupils commented that the restrictions hampered legitimate learning for their school subjects: "Remove all the restrictions on the internet so I can research work for subjects, for example, computer games where I can't research any games because it thinks I'm wasting time. So rather than saying 'no games allowed' put more validation on the domain checks to only stop websites with games that are playable rather than just all sites with games on them". Teachers shared these concerns, e.g."…IT puts up barriers to new Digital Learning websites that would be extremely useful in class and the turnaround time it takes to get these whitelisted is too long. The use of iPads has become negated due to the heavy restrictions and limitations put on them. The process of adding new apps and getting them approved takes too long is not worth the hassle."

Learners requested to learn more about digital topics in school as illustrated by these comments: "I think the school should teach me more in the areas of programming, using spreadsheets and running websites. Additionally, I think we should be taught in using programmes simulating running businesses and should be taught useful shortcuts and tips from using computers."

"I think it would be helpful to use digital learning more in school, as in most jobs you are required to use some sort of computer or other technology, and it would be useful to practise these skills in school." Some teachers expressed similar concerns on the learners' behalf, such as: "Children are not consistently being taught the skills needed to utilise digital technologies to support and enhance their learning."

Lastly, teachers reported that they would like better provision of training and development courses to improve their knowledge about how to support digital learning: "Staff training needs to be improved and increased CLPL opportunities for digital learning. Digital leads need to be coming into schools to support staff development and improve aspects of curriculum delivery". This was seen as particularly important for supporting learners with additional needs "Staff training is key in order for all teachers and ASN staff (and more!) to embrace the changes and see how much it can add to our pupils' learning especially those with ASN including dyslexia. It is not about more screen time but using screen time more meaningfully with real purpose…". Learners would also appreciate professional learning for teachers relating to technology: "I would like my teachers to be trained in using technology more efficiently, so we could advance in our learning."

Although this survey was conducted within a single local authority, consultation with digital services teams across the region confirms that these general themes are common in schools even although the specific details may differ.

2.4   Summary of Learners' Views

The young people at Data Town were very interested in the topic of data and wanted to learn more about it, particularly concerning the law and data privacy. Based on the Data Town participants' responses, it would be beneficial to give learners in the City Region more opportunities to use technology to support the data problem-solving cycle (e.g. creating graphs) to increase their skills and confidence in this area. The learners recommended investing in more laptops, tablets and (particularly for primary pupils) more robots. The snapshot from the local authority indicates that additional training or support for teachers would be beneficial, as well as faster turnaround times for white-listing websites and investment in the reliability of internet and wifi connectivity.

3 Technical Review: Connectivity

For the past twenty-five years, Councils across the City Region have continually improved their connectivity between schools and the outside world. Before the use of the computer network for learning, schools were connected for administrative purposes. As the internet developed and the use of cloud-based resources for learning and teaching expanded, connectivity has become the single most important technological factor to support learning through digital means. Throughout the world, in many schools, unreliable connectivity has become one of the most prominent disablers of digital learning.

A Scottish local authority has shared the results of a survey covering digital innovation and digital literacy in Quality Indicator 3.3, Increasing Creativity and Employability, from How Good is Our School 4. We have analysed the anonymised data to inform this report. Of 2,300 learners and teachers surveyed, 48% reported connectivity as the main priority for improvement in digital learning.

Connectivity between a learner and their cloud-based resource has many points of failure, so it is not an insignificant achievement to get it working every day. Most educational settings, including schools, further and higher education, experience challenges from time to time. The learner and the teacher is generally not interested in the reasons for failure but in the seamless operation of their technology.

Research, supported by the Scottish Futures Trust, is currently underway in Scotland to identify what attributes should be present in a school wifi system and how best these can be maintained to give optimum connectivity to learners and teachers.

3.1 WiFi – Wireless Networks

Wifi has been available in most City Region schools for the past 15 years, and in recent years, it has begun to contribute significantly towards learning and teaching. Wifi in all six Council areas is provided to schools by the Council or their contracted provider. Some schools, especially those with an integrated public library service, may also have an additional system provide by a third party. There are also a small number of locally deployed services in classrooms, but this is not popular due to the cyber resilience risk.

Learning takes place not only in fixed spaces in an educational setting but anywhere within that space and beyond. Wifi connectivity, therefore, has to meet that need and extend as far as is affordable and technically possible.

The expectation of the public to have good quality connectivity to the internet in public spaces and the move towards a more mobile workforce in business has driven the need for a range of high-performance enterprise wifi systems. School deployments have benefited because of the reduction in the purchase cost of high-quality systems.

Some Councils have contracted out their provision of Wifi, and this usually delivers a quality service as the provider has access to specialist staff and becomes highly competent in the delivery of a robust system. It can, however, also come with challenges around the affordability of a comprehensive system that includes good coverage and capacity.

The movement of pupils around the school is a technical challenge for any Wifi solution, and that movement is not similar to a typical business or commercial setting. Wifi providers are producing complex systems that can cope with the movement of individual devices across their cell architecture, retaining video and other streams. It is unlikely for this to be essential in a school environment, although different challenges are proving to be similarly, technically difficult. One such problem is the sudden mass movement of multiple, often sleeping devices from one classroom to another nearby. In high-density areas such as neighbouring English and Mathematics departments, where schools have a one-to-one deployment, there may be 300 - 400 devices on the move but still within reach of the original wireless access point.

Another such challenge is a significant change in bandwidth when a teacher refers a class of 30 pupils to a multimedia resource on the internet. An otherwise coping wireless Access Point becomes swamped with video streams.

The operating system and application updates of multiple school sets of devices such as iPads and Chromebooks also have to be factored into the bandwidth profile. Storage trolleys, each housing up to 30 devices, tend to be parked either individually in staff bases or multiples in resources rooms. A Mobile Device Manager can effectively manage updates but finding an update window is often a challenge.

Most public service organisations separate their wifi provision into virtual networks, mostly with a Service Set Identifier (SSID) or similar assigned to each group of users or group of devices. West Lothian was one of the first Education Authorities in Scotland to offer widespread WiFi with a Learning Channel in their schools. In 2012 they launched their Anywhere Anytime Learning (AAL) service, and it has been honed over the years to provide a very effective foundation for learning and teaching with mobile devices. It has been so successful that new schools are being built with a much-reduced wired capacity, with a preference for mobile wherever possible.

3.2 (Mobile) Device Management

Due to schools' continual need to stay on the cutting edge of technology, device management in schools will always be a challenge. Achieving a balance between locking down configurations to ensure useful functionality or enabling accessibility and flexibility to empower the learner and teacher, is difficult.

A Device Management System deploys instructions to the end-point devices which enable or disable features and functionality. It also ensures that the device remains securely connected to the network. There are several Device Management products in operation across the City Region.

Generally, there is consensus that Microsoft's System Centre Configuration Manager (SCCM) is the best system for effectively managing domain connected windows devices on the Local Area Network (LAN). Council and managed service providers are comfortable that the tools contained within the system are practical and good at managing the risk around connectivity.

There is also a consensus that Google's Administration Console is the best and most effective way of managing Chromebooks and other ChromeOS devices. East Lothian hosts its own Google domain and has full control over all of its ChromeOS devices. Midlothian, another extensive user of ChromeOS in the City Region, uses the Glow linked Google Admin Console to manage its ChromeOS devices.

Beyond the network connected MS Windows desktop PCs, Laptops and Chromebooks, there is less of a consensus on which are the best products to use. There is also a difference between some technical support service's desire to use a standard product across many device types and emerging decisions to use "best of breed" for each product range.

The former method brings less overhead on the support services as staff become familiar with one product. That can also carry less risk during change management. The latter tends to deliver a more technically sound solution for each product range, especially around device operating system updates and compatibility with the Mobile Device Management (MDM) system.

At the time of publication, several other MDMs were in pilot or production phases within the City Region schools for specific device groups. These include Airwatch, JAMF, Cisco Meraki, Radix and Intune.

While Council and school-owned devices receive a payload from the MDM that will control access to settings and functionality, the situation surrounding learners and teachers own devices is quite different. These devices are often entirely managed by the learner and teacher but need some sort of connection policy that ensures a safe and secure existence on the WiFi network.

No City Region Council has allowed access for learners and teachers' own devices to the wired network. All devices have to connect wirelessly.

3.3   Connection to Scottish Wide Area Network (SWAN)

For almost fifteen years, Scottish Education Authorities have had their connection to the internet supplied by the Scottish Government, originally through the SSDN (Scottish Schools Digital Network) and now through the SWAN (Scottish Wide Area Network) service.

The Scottish Government through Education Scotland is currently providing 53 individual circuits totalling 31Gbps into Education Authorities and other education-specific agencies.

Councils and other organisations can top-up their connection, providing additional bandwidth and connections at their own cost. Although the original Scottish Schools Interconnect, as it was known, was for schools only, it is now often used for other Council services and in particular for learners in libraries. Councils can also adopt the connectivity model provided by their WAN contractor, which might involve individual school breakout to the internet or a breakout to the internet provided within the contractor's infrastructure.

3.4   Wide Area Networks (WAN) within each Council Area

The Wide Area Networks (WAN) covering the City Region schools has developed both in topology and in bandwidth over the past twenty years. Topology of the wide-area networks has been developing from extended star to ring or virtual ring.

Although there are some Council owned private circuits in place, generally fibre and point to point radio circuits, all six Councils work closely with one or more contractors to deliver their WAN connectivity. The City of Edinburgh, has almost completed a roll out of fibre connectivity to each school. East Lothian was one of the first Councils in Scotland to take advantage of the unbundling of telephone exchanges, enabling flexible connectivity over existing infrastructure. Other Councils are developing models that fit their own needs including geography and availability of commercial partners.

3.5   Local Area Wired Networks

Most schools began to have their LANs (Local Area Networks) installed over 20 years ago, principally in those days for connecting the administrative computers. Wired networks have been rolled out across all schools in the Region and most schools, stretch to almost every indoor learning space.

Since some schools are often cohabited by Council staff and staff from other partner agencies, there are usually several physically or virtually separated local area networks. These are generally grouped, as shown in the following table.

LAN	Features
School Network	Most of the desktops and laptops (when cradled) connect to this network for their day to day connectivity. It is where the learners and teachers connect devices for accessing local and cloud-based services.
Corporate Network	Traditionally, most Councils have operated two distinct sets of services, one into corporate services and the other into schools. Non-school based staff such as council officers that have access to desktop computers reside on a corporate network. These computers generally have a more extensive range of security protocols, allowing the assets to be connected to resources on the Public Services Network (PSN)
Libraries/Public Network	Some Councils create a Libraries or Public network offering a range of connectivity and services to library and otherwise public access devices in Council buildings. When the original network designs where being constructed, it was thought that the library users would need some sort of separation between the school pupils and the general public. Across Scotland, some Councils have concluded that Library users can be considered as learners and therefore sit on the schools' network.

Table 7 Physical and/or virtual Local Area Networks in Schools

The latest networking technology doesn't always require the physical separation of networks as connectivity can be delivered through device and user policy. However, historic and best practice determines levels of separation, in particular to any connectivity to the PSN (Public Services Network) via a Council's corporate network.

Integration of services agenda enables close working between several agencies around schools. It is usual to find staff from various partner agencies such as Police, Health and Social Work either based in school or a frequent visitor, requiring some access to resources and connectivity.

Connectivity from the schools' network or corporate network to the police or health networks is secured by software/hardware provided and controlled by these services. There is also likely to be some physical security around the locations of the devices used to connect to these networks.

In Scottish Borders the school Senior Leadership Teams and school administration are located on the corporate network. The rest of the school is connected via a curricular network. In all Councils, school-based staff straddle the schools and corporate networks depending on their role and whether they need secure connectivity with Social Work, Police and Health.

3.6   Cabling Infrastructure (Copper and fibre)

The cabling infrastructure in the Region's schools has grown over the years and replaced and upgraded as required. Connectivity now covers most learning spaces in most schools and has required significant investment from Councils beyond the initial funding from the Government.

While the move to enterprise WiFi availability in almost all schools, the proliferation of wired network points is beginning to diminish. Data points are still being installed in schools. These are primarily in new build areas, to connect wireless access points or to deliver services that are individually available on wired networks.

Cabling infrastructure in schools is no different to that in business. Internationally agreed standards are adhered to, and these cables are generally professionally installed and tested to ensure the quality of service.

The topology within a school, as in business, will depend on the layout and size of the building. In small schools, all data points will be connected by copper network cable back to a central communications cabinet.

In a large secondary school, the cabling infrastructure will be a combination of fibre and copper network cable, most likely in an extended star configuration. In this topology, there will be multiple cabinets to which the data sockets are connected by copper network cable. These cabinets are then connected to central cabinets, in a room often called the Central Comms, by fibre optic cables. The size of the connecting cables and the design is reflected in the size of the building and the number of services that will be contained in each sector.

3.7   Identity Management

One of the most critical functions on a computer network is to identify the user and device then give them connectivity and access to appropriate services. Users are recorded in directories, and these directories can be trusted across several domains. For example, if a trust is placed between a school's directory and the Eduroam services, any college or university students and staff also registered with Eduroam may get wireless connectivity without additional work done to identify the user. Similarly, once a school joins Eduroam, its pupils and staff can have access to any Eduroam registered academic network across the world.

Pupils and teachers regularly have to log in to services, and in the interests of simplicity, there should be an attempt to minimise multiple logins. In most of the City Region, access to Glow or Google Services will require a second login once the user is logged into the desktop or laptop. The exception to this is where the pupil or teacher is using a Chromebook, and the login takes them directly into the Google services.

3.8 Connection to 3G/4G/5G networks

Learners and teachers will connect to the internet through their own devices, using their individual data contracts. Although principally for personal use, some of the connectivity will inevitably be used for learning and teaching.

Some schools are embracing the availability of personal technology to support learning and teaching, while others are banning its use within the classroom. Many teachers are understandably nervous about its use within the classroom as it can lead to indiscipline. Others are more comfortable with this, seeing it as a useful extension to the toolset available to learners.

3G and 4G connectivity is available in most communities across the City Region, and 5G is beginning to roll out in urban areas. The use of 3G and 4G in very old or new-build schools is often compromised due to the construction of the building. Communication masts that adequately served older schools are not in the correct position, or the fabric of the building is sufficiently disruptive to make its use haphazard.

Beyond learning and teaching during the school day, a source of contention in schools with compromised 3G/4G connectivity internally, are large public gatherings. Parents evenings, school concerts, community events and elections all bring large numbers of people into schools, many of whom feel aggrieved with little connectivity.

There are new technologies that would assist 3G and 4G connectivity within school buildings, typically used in train stations, airports and other public buildings. Schools have not yet taken advantage of these solutions.

4 Technical Review: Digital Technology in the Classroom

Across the City Region, there is a wide selection of digital technology in use in our classrooms. Schools are continually pushing at the boundaries to introduce the latest and most appropriate technology to support learning and teaching.

Digital Learning Strategies are moving more of the purchasing decisions into the hands of Headteachers, and this will encourage more diversity in technology. This report covers some but not all of the technology in use in the City Region's schools.

4.1 Windows Standard or Small Form Factor or Mini PC

Desktop PCs remain a popular choice of technology across all City Region schools. However, schools are increasingly moving away from the bulky standard desktop in favour of a smaller form factor. The size of table tops and the space taken up by furniture is decreasing in new-build learning spaces, in favour of more flexible spaces. The desktop PC and screen has to become more space-efficient.

Pupils will use the technology in a variety of ways, generally having other resources to use alongside the computer. Having space to move the keyboard and mouse back or to use a jotter alongside the desktop computer is essential.

A decrease in size of the PC has come with a compromise on the availability of built-in DVD players, and the accessibility of DVD and sound ports as the smaller form factor PCs are often tucked behind the monitor.

The Desktop PCs in the City Region schools are almost exclusively Microsoft Windows-based, a variety of operating systems with most Councils striving to achieve Windows 10 as soon as possible. The desktop PC gives a stable platform for a wide range of software that can support learning and teaching.

Some Desktop PCs are grouped in clusters in or around classrooms and some are grouped to make up a class or half-class set. The computer room filled with desktop PCs is disappearing in primary schools in favour of having more PCs adjacent to or inside classrooms. Secondary subjects such as Business Education, Graphics and Computing tend to be timetabled into a computing room wherever possible.

Nearly all Windows desktops are locked down to a profile set by the technical support provider, and there is little flexibility for learners and teachers themselves to add software or significant change settings locally.

4.2   Apple Mac mini / iMac

The use of Apple desktops in many Scottish Education Authorities diminished over the past 20 years when the responsibility for Education and technical support transferred from regional to unitary authorities. This was mainly due to the support services being less confident and experienced with Apple technology, and a shortage of Apple qualified technical support personnel in the job market.

Those that have retained Apple desktops have found them to be very useful for many aspects of learning and teaching. Other are beginning to look at the return of Apple into the classroom as it has such a successful track record throughout the world. It is also the primary computing tool in the creative design and music industries.

Apple's desktop range comes in two possibilities for the classroom. Firstly, the Apple iMac which is an all-in-one unit with the computer built in with the display screen. Secondly, the Apple Mac Mini, which is a small form factor device that needs a keyboard, mouse and display to function.

4.3   Thin Client

A thin client is a small computer (not unlike a mini PC) that connects the user's screen, keyboard and mouse to a much more powerful computer in another location. The software that is used generally sits on a service elsewhere in the building or indeed the cloud.

Although the concept of a thin client is sensible, there have been many problems rolling them out as fully functional computers for the curriculum in schools. This is primarily due to the pace of change in learning technology and the need to connect a wide range of devices to the computer. Thin clients are much more likely to be used in an office type environment with a restricted number of applications like MS Office and those that are web/browser-based.

The concept of a thin client that connects to a server running applications that are user dependant is sensible for many school applications and future developments in virtualisation software will no doubt engage learning technologists in years to come.

4.4   Workstations or desktops with more processing power

More powerful workstation-type computers in schools are uncommon, except for the occasional bespoke solutions in secondary computing and design technology departments.

Emerging in schools, however, are a few applications where a desktop computer may not be able to cope with the amount of processing that is required in a short space of time—for example, the data surrounding 3D scanning, 3D printing, virtual design and 3D rendering.

All Councils offer an increased specification or an upgrade path for desktops or towers that are required to do more substantial processing for the curriculum. In the City of Edinburgh, Fife and Scottish Borders schools, enhancements are available within their catalogue of devices. In other Councils, the technical support services will look at each request and perform upgrades where appropriate.

4.5 Laptops (Windows Operating System)

Windows laptops are a popular solution for teacher use in schools where the teacher may want to remove their device to the staffroom or home to continue work. Windows laptops are not used extensively by pupils in most schools, although there are still some class sets around. Windows laptops are the device of choice for many assistive technology applications.

Nearly all windows laptops are locked down to a profile set by the technical support provider, and there is little flexibility for the learner or teacher to add software or significant change settings locally.

4.6 Netbooks (Windows Operating System)

City Region schools, for many years, have used a range of stand-alone netbooks. These were becoming less popular due to instability and the workload of supporting non-domain connected devices. Although the netbooks had a shorter life-span than laptops, the lower cost made them attractive.

The downward trend may be reversed as Microsoft Windows 10 becomes more cost-effective and easier to support for these low-cost solutions. Many netbook type solutions will likely be replaced with Chromebooks in Education Authorities where Chrome OS is available.

4.7 Tablets (Windows Operating System)

Microsoft Surface devices are now coming into an acceptable price bracket for schools. There is a range of flipping devices available on the various purchasing frameworks, and if the price point continues to drop, there may be more of an incentive for schools to use them.

4.8 Chromebooks

Chromebooks have been available since 2010 and are lightweight browser-based laptops. Applications reside in cloud servers driven by Google and others. Worldwide, use in schools has recently increased dramatically, and in some areas, the Chromebook use far outstrips other devices.

In Scotland, Chromebooks have been deployed in many schools. School use is likely to pick up pace now that the national intranet, Glow, offers authentication into G-Suite via the Chromebook.

4.9 Chrome Tablets

Chrome tablets first came to Scottish schools in 2018 and are set to become a competitor for the iPad. This market is likely to increase over the coming years. Chrome tablets give the same functionality as a Chromebook, just with an on-screen keyboard.

Chromebook manufacturers are also introducing a flipping Chromebook to combine a tablet with a traditional netbook. These are likely to be less robust for classroom use but never-the-less popular to have a tablet and a keyboard in one device.

4.10 Apple Mac OS laptops

Macbook Pro laptops are trendy in education environments throughout the world. In Scottish schools, with the widespread transfer of support for digital technology in schools to corporate IT departments, the use of these devices has reduced due to a lack of Apple qualified engineers in the support role.

It is unlikely that City Region schools will deploy large numbers of Mac OS laptops due to comparative costs, but it remains the device of choice out with school for many senior pupils and teachers.

City of Edinburgh, Scottish Borders and West Lothian schools can purchase Macbook Pros and Airs and connect them to the BYOD/AAL networks.

4.11 Apple IOS devices

Most schools use iPads, and many have used iPods to support various aspects of the curriculum. These devices are reliable, manageable and can be deployed in several ways. Ipads have been particularly popular when supporting youngsters with additional support needs and early years. Scottish Borders is rolling out a large number of ipads with some being used 1 to 1.

4.12 Kindle and other e-readers

Many schools have avoided e-readers due to the difficulty in managing such devices detached from a credit card. However, teachers continue to examine whether there is a role for low-cost tablet-style devices, especially for reading pdfs and other e-formats. As schools have found ways to manage these devices safely, we see an increased number coming into schools.

As ownership and connectivity of personal devices increase significantly, e-reading will be an integral part of any provision on a learning platform. Many library services have developed their e-library offerings in both text and audio.

4.13 Monitors and Screen Estate

The size of the monitor used on desktops and as a second screen for teachers' laptops has crept up in size and changed in aspect ratio with industry standard. It is now commonplace to find 21" or higher displays in schools and most are moving towards a 16:9 aspect ratio. Some schools are researching larger displays, 23" and 24", in particular for fine graphical detail or multiple windows.

Some staff, generally in administrative roles, are using twin monitors, or an additional monitor attached to their laptop, to increase their screen estate and reduce continually collapsing and opening on-screen windows.

4.14 Filespace and other Network-Based Applications

Each Education Authority has a strategy for how it deploys file space and other applications to its learners and teachers. Some have servers in each school, and others have servers deployed centrally and increasingly, schools are looking maximise their use of cloud-based storage and applications.

The strategy to successfully deploy servers out with the school relies on stable and effective connectivity being in place to ensure that the server is available at all times.

Ahead of most Scottish Councils, the City of Edinburgh adopted Microsoft Office 365 as their cloud-based applications and storage platform. Across the Council, learners, teachers and other staff have access to a wide range of cloud services.

The Scottish Government offered Microsoft Office 365 (M365) within the Glow environment, available to all pupils, teachers and others working in Scottish classrooms. More recently, G-Suite and Google Drive were added to Glow, available on an opt-in basis for all schools within Scotland.

Most pupils and teachers in Scotland are now moving their storage needs to cloud-based services such as O365 or Google Drive. However, although the security and resilience available in these cloud-based systems usually exceeds that deployed in locally managed servers, there is currently a restriction on the sort of information can be stored in the cloud. Primarily this is due to the lack of endpoint control in personal devices connected to the cloud space.

4.15 Casting technologies

As more mobile devices are used within the classroom there is a need to cast or stream the content from individual devices onto the large LCD screen, projected image or subsidiary screen. Various technologies can be used to do this, but these don't always fit well together. Most casting technologies rely on the contents transiting via the wifi and/or wired networks, and therefore this requires significant technical expertise and some network security risks.

Various casting technologies are emerging within the Edinburgh City Region schools, ranging from the free-to-schools through to per-device license options. Some require hardware alongside software to work, and others are software only. The most popular products used in the Region's schools at present, although this may change as the mobile devices and large-screen display options develop, are Apple Airplay, Google's Cast for Education and the in-built options from Promethean, Smart and Clever Touch interactive surfaces.

4.16 Browsers

Since many applications are moving from local processing on the client computer towards remote delivery from external servers, the local application that connects the user to the remote application becomes critical. Almost all client computers connect to these applications through a browser. The functionality of the browser and the version control thereafter becomes critical to the successful delivery of learning and teaching. Most Edinburgh City Region schools use Microsoft Edge or Internet Explorer or Chrome, and some have access to Firefox on request.

4.17 Large Interactive or Non-Interactive surfaces

There are many different types of interactive panels being sold to schools in Scotland. The three most popular products in the Edinburgh City Region Schools are Smart, Promethean and Clever Touch. In the past, most of the City Region's learning spaces had an interactive whiteboard. Some of these are now being replaced by interactive LCDs and others by non-interactive LCDs.

The manufacturers providing most interactive surfaces into the City Region's schools have increased the complexity of their products, and each now offers an in-built computer and a range of applications from casting through to learning management software.

The use of interactivity on the board or screen has recently been a topic of discussion around pedagogy. Although learners and teachers in primary schools tend to make extensive use of the interactivity on the screen, many secondary teachers don't use the interactivity on the surface, and the products are used as a large display screen. There are notable exceptions, for example maths where learners closely follow the teacher doing something in detail. Also, where enthusiastic staff have provided training and support to their colleagues, interactive surface use increases substantially.

Some schools are now deciding to replace interactive surfaces with non-interactive displays. These are often less expensive than a comparably sized interactive display. Interactivity within some classes is moving to the learner's mobile device with the ability to cast the screen content onto the large display.

4.18 Digital Signage

For the past fifteen years schools have used LCD panels or large LCD TVs to broadcast content in foyers and dining spaces. Many new schools are built with strategically placed digital signage so that learners, teachers, other staff and the wider community can be updated with appropriate information.

East Lothian schools piloted the use of Google Casting for Education to deliver content onto display signage. Other Councils are using commercial products such as OneLan to create and schedule content onto screens. Some schools have gone for a much simpler solution of connecting the screen to a netbook or plugging in a USB memory stick with photos and movies to the USB socket on an LCD TV.

4.19 Mixed Reality Technology

Google VR has been available and used in the City Region schools for five years. Teachers used it as a fun way to introduce digital technology in the classroom, but lately, it is more integrated into the curriculum. The VR application typically runs on an IOS or Android-based device and is housed inside a cardboard or plastic case. The teacher's iPad or other tablet is used to drive the expedition for the learners.

The world of 3D mixed reality almost has no boundaries and can transform the learner's experience into the virtual-world and beyond. This ranges from the creation of three-dimensional objects that can be tested in the virtual through to the most complex of journeys through the human body.

The availability of mixed reality application in an easily affordable form for schools is bringing an increasingly diverse set of opportunities in the curriculum. Learners can create in the virtual space and when ready and if necessary, transfer into the real world.

Many schools across the city region have experimented with virtual reality, and fewer have experience augmented reality applications. Learning technologists foresee that augmented reality, once reduced into lower-cost platforms, will allow learners to experience a much more comprehensive and useful range of experiences.

4.20 Robotic and other devices

Schools have used robotic devices for the past fifteen years, but the increased complexity of newly developed products and extended use within the curriculum are just beginning to emerge. Some Education Authorities have organised loan banks, and these have been popular with schools as the devices are not used continuously with learners. The pace of change of devices is also a problem with new products entering the marketplace continuously.

Most secondaries and some primaries are now experimenting with Making, using microcontroller modules like Micro:bit and Arduino, with some venturing into building projects using Raspberry Pi computers. There are significant interdisciplinary opportunities around the use of these devices, and this is likely to expand in the coming years.

4.21 Online Learning Environment, Glow and others

In 2001, the Scottish Executive, the devolved UK administration at that time, brought a group of Educationalists together to design a learning management system (LMS) for Scottish schools. The resultant product, Glow, has gone through significant developments since then.

Schools in West Lothian, Fife, Midlothian and Scottish Borders make use of Glow as their online learning environment. Edinburgh uses their own tenancy of Microsoft Office 365 but is also encourage schools to make further use of Glow. East Lothian schools have focussed mainly on Google Classroom, but recently the digital learning strategy has also focused on extending the use of Glow.

4.22 Content Delivery Services

There will always be the need to deliver rich multimedia content into the classroom as part of teacher presentations or indeed, individual pupil viewing. Many resources are available openly on the internet, but some require a pay-to-view service.

There are several providers of pay-to-view services, and one of the most popular in UK schools has been Clickview. Schools can record from free-to-view sources, edit then publish content. Several other features are also available within the mainly web-based services.

Clickview is one of the services that can be authenticated through Glow and clips can be embedded in a virtual learning environment.

One of the most challenging aspects of serving content from high-quality video sources is being able to apply appropriate filtering. For example, there are lots of excellent resources on Youtube, but schools' ability to remove inappropriate content is quite limited.

4.23 Other Cloud Software

For the past 20 years, most creative software has run locally on desktop PCs. Increasingly, software vendors are delivering cloud-based solutions or cloud-based solutions with a local lightweight application. This type of solution is welcomed by schools as it often extend the viability of older devices.

4.24 Social Media

Social media applications such as Facebook, Twitter, Instagram and blogs are used extensively in schools. Many individual teachers are also active on Twitter and blogging platforms with work-related content. School websites are hosted on a number of different platforms. Some schools use a blogging platform and engage groups of writers from within the school population. Other have a more formal presence with all publications coming through the school administration. A small number of schools engage a commercial provider to create and support their website, mobile app and other media links.

4.25 Content Filtering

Content filtering and delivery are vital in all education settings. The latest filtering technology makes dynamic decisions on whether to serve content dependent on many criteria. These systems also offer extensive reporting systems that can identify not only threats to the pupils and staff but also where browsing activity brings risk to the individual in respect of safeguarding or the wider community in respect of the PREVENT agenda.

All City Region schools use the enterprise filtering system offered by their Council's technical support service and all Council prioritise filter changes where access to educational content is denied.

4.26 Video Conferencing and Streaming

Video Conferencing is an essential resource as it can connect pupils and staff to the world outside school. Skype for Business is included within Glow for teachers and therefore, low-cost web cameras and skype functionality should be possible in and around the classroom. West Lothian schools make extensive use of the Skype for Business client through Glow. This session, some trials are taking place, teaching across schools.

Some schools are now using Ajenta, an Edinburgh based company's VScene video conferencing solution to deliver voice and vision connectivity with others or groups of others across education establishments, throughout the country and beyond. The VScene solution is used for the Comhairle nan Eilean Siar's E-sgoil (Western Isles Council e-school)

Several Education authorities in Scotland are looking to record and share classroom activities for a variety of reasons including minimising travel for minority subjects and mitigating the risk of teacher shortages. This practice also helps to support pupil absence and catch up.

4.27 Video and Sound Production

Although some schools continue to explore the professional aspects of video technology, it has not been commonplace in schools due to the cost of hardware. That is now less of a problem, and some reasonably cost-effective options are available to record broadcast quality images. For example, many schools are using cameras on tablets or phones to film content. Depending on the device, the quality of the recording can often be of exceptional quality.

Pupils in primary schools are likely to have used video editing applications to do ad-hoc editing to produce a film for a class project.

4.28 Printing

Printed media is an essential part of learning, and there are numerous curricular applications where it is still required in the classroom. Many Councils have deployed corporate printing solutions and have rationalised printer use in schools. Typically, schools will now have fewer print options, and many will be located outwith the immediate reach of learners. It is now common for teachers to print to the central MFD (multi-functional device or office photocopier), taking advantage of lower cost, better quality printing.

Some schools need to deploy printers in classrooms where it is not possible for the pupils to travel within the school to obtain a print. Art, CDT and other design applications in school often need A4 or A3 colour printing at ad-hoc times throughout the school year.

Most schools have had one or more photocopier and these devices have gradually been replaced over the past five years with multifunctional devices, offering scan to print, scan to email, scan to file and networked printing. Some schools have deployed secure print options for staff where the member of staff has to identify themselves to the printer before printing can happen.

The concept of 'follow-me-printing' and cloud-based printing solutions are being considered in some schools, especially where there is a significant community element.

3D printing is now commonplace in secondary schools and some primary schools. The use of 3D printing is expanding as teachers find new ways to introduce it in the creative curriculum.

4.29 Coding Platforms

There are several hardware and software platforms used within schools, partly to develop core computing concepts but also to widen access to digital technology.

In Primary and Special schools, there are robotic devices such as floor turtles that learners will use to develop some core computing concepts. Collections of more complex robotic devices are available to borrow from some local authorities. Primary and Special school learners are generally introduced to more advanced coding through online environments such as Scratch.

Most secondary schools use an assortment of microcontrollers or single-board computers such as Micro:bit and Raspberry Pi in maker activities, digital literacy or computing classes. They also use a variety of coding environments, local and online, particularly in Computing Studies.

5   Digital Learning, Technical and other Support

Digital and other technologies are integral to learning and teaching. Since the early 1980s, schools have used digital technology in a variety of ways to empower learners. In the past five years, the possibilities around learning through digital have increased significantly due to the personalisation of technology and emerging, innovative technologies that share experiences across the planet.

It is widely accepted that the use of technology in schools is substantially different from most other applications, requiring a specialist skillset to deliver a wide range of support to people as well as technology.

5.1   Additional Support Needs

Schools have access to a range of digital technologies to assist learners with additional support needs to access the curriculum. Making learning accessible for all is not only good practice in terms of the Scottish Government's GIRFEC (Getting it Right for Every Child) policy but is also enshrined in equality legislation.

Where new educational programmes are developed, such as the Data Education in Schools, resources must be accessible. CALL Scotland gives a wide range of advice on the use of technology to enhance the learner's experience and produces help-sheets for technology typically used in schools.

Across the City Region, the extent of assistive technology interventions vary. Although there is good evidence of technologies being put in place to address accessibility across the curriculum, in aspects of data education and computing, progress is limited. Some Support for Learning departments in schools have embraced the accessibility tools available within Microsoft productivity software, iPads and Chromebooks. Others have invested in specialist hardware and software to support learners

The level of complexity in the assistive technology is often difficult for teachers to cope with in the classroom environment, as is the ability of teachers to assimilate its use in a busy classroom.

5.2   Technical Support

Many Scottish councils have withdrawn their specialist school-based education technology services in favour of a centralised service. Some have contracted out their support service to commercial partners. Across the Edinburgh City Region, there is a variety of support strategies. Two Councils have contracted out their technical support to an external provider while the other four have in-house support services.

Although the services vary from Council to Council, most include an all-encompassing service from procurement through support to disposal.

Teachers still identify gaps in service that negatively affect learning and teaching, most probably due to the need for efficiency savings and the removal of services which are specific to the needs of the classroom.

Schools that have additional technical support in-house or have one of the Council technicians based locally, significantly benefit from their presence.

5.3   Digital Learning Teams

Councils have found it difficult to maintain learning and teaching specific support for digital, but there is no doubt that local services increase the positive impact of digital on learning.

The Digital Learning teams across the City Region work individually to support their own schools and collaboratively with other teams in the South East Improvement Collaborative and across Scotland.

The contact details for the teams are as follows:

Education Authority	Team or Designated Person	Contact Details
City of Edinburgh	Louise Sibbald Senior Development Officer Louise.Sibbald@ea.edin.sch.uk	https://digitallearningteam.org/ Wester Hailes Education Centre 5 Murrayburn Drive Wester Hailes Edinburgh EH14 2SU 0131 469 2999 @digitalCEC
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Table 8 Education Authority Digital Contacts

5.4 Procurement

Public service purchasing is governed by strict procurement rules which mean that almost all purchases made by a school, or the Council on behalf of the school, have to be within procurement tenders or frameworks. In Councils, a procurement service will tender for the supply of goods and services, either alone or in collaboration with other Councils. Procurement Scotland, the Government agency, also arranges contracts or contract frameworks on behalf of themselves and other public service organisations in Scotland. Most of the large volume items like desktops, monitors, laptops etc. are bought from suppliers specified on the national contracts. Competitive pricing is achieved, although it reduces the flexibility of schools to buy out with the standardised lists.

Where schools want to buy other devices, like Raspberry Pi, Arduino boards or other peripherals, the framework companies will give reasonably discounted pricing. Alternatively, some schools can go to online retailers where that is permissible.