The Impact of High-Speed Broadband in Irish Schools.

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics.

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Abstract:

The Irish government is investing in a high-speed broadband network for Irish schools, delivering 100Mb/s connections to every post-primary school over a 5-year period (2010-2014). This service is intended to underpin the development of digital education, promote ICT in the classroom and ultimately produce school graduates with the skills and aptitude to succeed in the digital economy.

This paper looks at the background to the project and examines the impact the provision of high-speed broadband is having in the schools that have already received the service, by way of a survey of relevant personnel in the schools (ICT coordinators and principals).

The findings suggest that, whilst schools are using the service in most subjects, and are sufficiently confident in it's reliability to integrate the internet into classes, other factors including internal ICT infrastructure deficits, and lack of training and support may reduce the potential impact of the project.

Keywords:

Information Systems, ICT, Schools, Broadband, Digital education, Cloud computing, Video-conferencing

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Glossary of abbreviations:

BYOD	Bring Your Own Device – whereby businesses or other organisations permit employees to use their own computing devices on the company network for business purposes.
DCENR	The (Irish Government) Department of Communications, Energy of Natural Resources.
DES	The (Irish Government) Department of Education and Skills.
ICT	Information and Communications Technologies
Mb/s	Megabits per second – a measure of connection speed for broadband connections (1 megabit = 1,000,000 bits).
MOOC	Massive Open Online Course – courses provided by universities and other higher-education bodies on the internet, often free of charge.
PDST	Professional Development Service for Teachers – Government agency responsible for teacher training and curriculum development (formerly NCTE).
VOIP	Voice over Internet Protocol – a method of providing voice telephony services over the Internet.

1 INTRODUCTION

1.1 Preamble

In 2009 the Irish government launched an ambitious program to provide 100Mb high-speed internet connections to all Irish post-primary schools within 3 years (Kennedy 2009). This was with the aim of revolutionising the Irish education system to provide

"*Personalised learning for each student … creating the inventors, the writers, the engineers and the businesspeople of the future*." (Ryan 2010)

The project is administered by two government departments, *Communication, Energy & Natural Resources* ("DCENR"), and *Education & Skills* ("DES"); alongside national education network *HEAnet*. It is due to be completed, with over 700 schools connected to the new network, by the end of 2014 (delayed from the original target date by the crisis in the Irish economy). This paper examines the impact of the high-speed broadband program on the schools involved, in the context of recent developments in education (both in Ireland and internationally) with a particular emphasis on the usage of ICT in schools.

1.2 Education in the digital age

Technological innovation has changed the environment and methods used in most industries to such an extent that students emerging form the education system today enter a professional world that is unrecognisable even from that experienced by their parents just a generation ago. The educational institutions they are leaving have not changed to the same extent; modern classrooms in most schools are still recognizably the same as those from a century ago, with a teacher standing at a board lecturing to students sitting in rows, though the board may now be an interactive whiteboard connected to a laptop, rather than the traditional blackboard and chalk. (Puttnam 2014)

Innovators in the educational sphere are questioning whether the traditional model is fit for use in the modern world, where many jobs require the ability to think and solve unstructured problems logically and work *with* information, rather than memorising information and procedures. Many of today's students may find themselves doing jobs that don't yet exist working with technologies not yet invented (Levy and Murnane 2014). This is particularly pertinent in Ireland where the government has focused on job creation through direct investment from foreign multinationals, many of which are at the cutting edge of modern information systems. Google now employs around 3000 people in Dublin; Amazon, Facebook, PayPal and other pillars of the modern digital world all have a significant presence in Ireland.

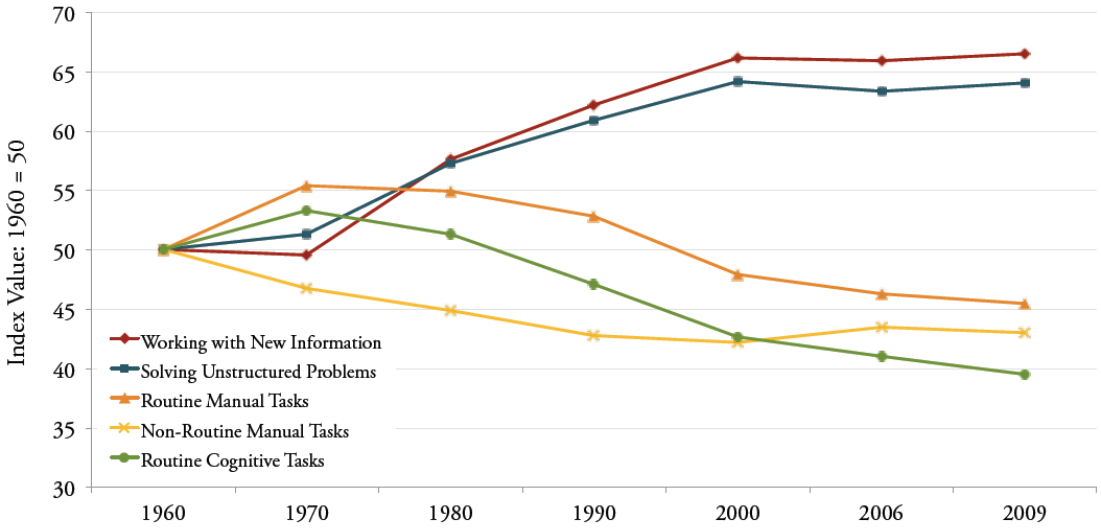

Figure 1-1 "Changing Work Tasks in the US Economy"

Source: Levy and Murnane "Dancing with Robots" (2014)

The National Digital Strategy for Ireland envisages a society where digital technology is pervasive in areas such as business, education, social engagement and interaction with government (DCENR 2013a). In order to accelerate progress towards these goals, the government in 2012 appointed former filmmaker and longtime digital education advocate Lord David Puttnam in an ambassadorial role of "Digital Champion", with a remit to be an evangelist for the adoption of ICT in all areas of Irish society but particularly in education.

Lord Puttnam in a recent talk on digital learning cited the example of the Times Education Supplement's online repository "TES Connect" which allows teachers to share lesson plans and resources and enables other teachers to gain from the experiences of their colleagues in using internet resources to change the way classes are conducted. Just 4 teachers have uploaded 6000 lesson plans that have been downloaded 7 million times across Europe. Puttnam makes the point (as have others working in this space) that merely digitising old practises does not harness the potential of the technology - e.g. moving from paper to eBooks may reduce the weight students have to carry on their backs but if the eBooks are straight digitisations of the paper editions they are replacing, they are not adding anything to the educational experience (Puttnam 2014).

Whereas in the past computer use in schools generally implied a visit to the computer lab specifically to learn how to use computers (McGarr 2009) many students are now acquiring a high degree of ICT knowledge through usage of technology in everyday life, and schools are seeking to utilise ICT in the delivery of the general curriculum. ICT is now available to be used as part of every subject, rather than being a subject on its own;

though outside initiatives such as CoderDojo continue to promote the development of computing skills amongst children (CoderDojo 2014).

Dutch educationalist Jelmer Evers has outlined a radical re-imagining of the school and classroom environment, utilising digital technology and the increasingly popular "flipped classroom" approach to reconfigure the teacher-student relationship along Socratic lines; and to use the prescribed curriculum material in various subjects to generate cross-functional projects for this students utilising the latest technologies (Evers 2014). *Flipped classroom* aims to make time spent in the classroom more effective by moving the delivery of the lesson online via a video – or other material – that can be accessed at any time; and reserving class time with the teacher for more productive reinforcing of knowledge through exercise, practical application and discussion. In essence the lecture becomes homework and the homework takes place in the classroom (Brame 2013). The aim of this innovation is to move away from the teacher-led "sage on the stage" style learning that has dominated pedagogical practise for centuries towards a student-led approach that caters for the differing interests and talents of the individuals in the class.

Schools such as Evers' own UNIC school in the Netherlands and Californian school group "High Tech High" are putting some of this theory into practise today (High Tech High 2013). The adoption of digital technologies in the classroom enables this sort of restructuring. Research in Ireland has shown that the flipped classroom idea, whilst something of a buzzword in pedagogical circles, can be effective in increasing students interest and interaction with the material being taught, as well as in promoting greater collaboration between students (Kirrane 2013).

Some existing Irish schools are already using ICT to change the way certain subjects are being delivered; Meath ETB (formerly VEC) runs multiple post-primary schools and is providing applied-maths lessons in those schools which have previously not offered this subject by using video-links to teachers in schools where the subject is available. Extra tuition ("grinds") is also offerred by giving students access to lessons on a online virtual-learning environment (Kennedy 2011).

Many excellent online resources have been created for teachers and students such as iTunes U, YouTube for Schools, TES connect and the ever increasing number of MOOC ("Massive Open Online Course") modules available from major international universities (EdX 2014). To fully utilise these, reliable broadband is an absolute requirement, but with broadband in place and the necessary supporting technologies it is possible to envisage schools building their own curriculum using online resources and moving away from traditional schoolbooks (either in paper or electronic form).

1.3 Student attitudes to ICT

Students increasingly have ubiquitous access to the internet for accessing information of all kinds when in the home, and on the move via mobile devices, and the current rollout of 4G mobile internet services will greatly enhance the services available on the move, making mobile video and television services practical for many users. There is a danger of a disparity growing between students' access to information in the outside world versus a more restricted access within the school, due to technological restrictions or outdated teaching practices. It could be argued that teaching kids ICT in the traditional sense has become redundant, as they may already know more about it than the teachers. Children may arrive for their first day in school with a degree of digital literacy that would have been unthinkable even 10 years ago, as shown in a recent study for Ofcom in the UK (Garside 2014).

The "Net Children Go Mobile" project is a multinational study of the attitudes, behaviour, risks and opportunities generated by the use of mobile internet by children both in the home and the classroom. The most recent report (Mascheroni and Ólafsson 2014) includes comparative findings from studies in Ireland and 6 other EU countries, focusing in particular on exposure to risk, in relation to how mobile internet access is moderated for children. Previous studies have shown that greater usage of the internet, whilst presenting increased opportunities, also leads to increased exposure to "risky" experiences and the recent report data extends this finding into the area of mobile access.

Amongst the findings in relation to Irish children is that they are relatively more moderated in their use of mobile internet devices; i.e. they use them under parental or teacher supervision, with less access in private areas such as their bedrooms or whilst outside the home. Whilst the study shows that in some of the other countries, less moderation is associated with higher levels of exposure to risk, and vice-versa, in Ireland it is not so clear-cut, with exposure to risk (defined as one of seven experiences that may have "bothered" the child) lower, but "harm" (how bothered the child was by the experience) higher than the overall median.

One finding that is perhaps not surprising is that children increasingly see their mobile devices, and smartphones in particular, as an extension of themselves, a device that they have on their person permanently and that is essential for communication at all times. This could present a challenge for schools, as they must decide whether to facilitate this desire for ubiquitous communication, and determine what if any restrictions should be put on mobile device access within the school environment. The study finds that Irish schools currently adopt a highly restrictive approach, with students generally blocked from accessing school Wi-Fi networks with their own devices, and teachers heavily mediating

internet access within the classroom. An earlier report within the same study found that internet use within the classroom was lowest in Ireland of all the countries surveyed.

Whilst it may not always be practical for schools to keep pace with the technology in use by students outside of the home, it could have negative educational implications if students feel they are "stepping back in time" each time they enter the classroom. Outdated, slow, or unreliable technology in comparison to that which the students use in their own lives could lead to a degree of skepticism in students about the relevance of the traditional education system.

1.4 Broadband In Schools

The introduction of broadband internet access in schools is widely considered to be a positive step, providing students with access to the vast range of resources available on the world-wide web and teachers with a powerful tool to enhance their delivery of the school curriculum.

The formal rollout of broadband in Irish schools started in 2005 with the setting up of the Schools Broadband Network by the Department of Education and Skills (DES). Prior to this some schools had already arranged for the installation of broadband on their own initiative but the DES program made this service available to all schools at no direct cost to the school itself. Around 3900 schools were connected as part of this project at broadband speeds of between 512 kilobits per second (Kb/s) and 8 megabits per second (Mb/s). These speeds were average for consumer broadband connections at the time and increased as standard consumer broadband products were upgraded over the subsequent years, with some schools receiving connections of up to 24Mb/s. (NCTE 2004; HEAnet 2010a)

However the connection types chosen for this project varied depending on the location of the school. Urban and suburban schools generally received higher-speed ADSL connections while more rural schools were connected using satellite connections, which in addition to being slower than ADSL suffered from high-latency making it difficult for schools to use their connections for certain applications.

Additionally all connections supplied to schools were based on home consumer products available in the market at the time. The sort of service-level agreements (SLAs) applicable to business products to ensure continuity of service and fast repair did not apply to these schools connections (primarily for reasons of cost). (Byrne 2005)

One consequence of this was that schools may not have felt in a position to rely on their internet connections with sufficient confidence to plan activities or lessons that required internet access, and use of the internet continued on a more informal basis, rather than

being embedded into the regular delivery of classes. Unreliable systems discourage use, and consumer broadband systems are not designed for reliability to the extent required by businesses.

It was with these drawbacks in mind that planning was started for a new Schools Broadband Network, initially for Post-Primary Schools, that would have two key features:

- Uniform, guaranteed high-capacity links (100Mb/s symmetrical), to ensure multiple classes could access the internet simultaneously.
- Business-class SLAs to ensure schools could rely on the service and plan activities around it. (HEAnet 2010b)

This project was launched in 2009 with a target of installing in all post-primary schools within 5 years. The technologies to be used are fibre-optic and point-to-point microwave wireless and the stated aims of the project are to:

- Incorporate the integration of ICT in teaching and learning across the curriculum
- Ensure that schools have access to modern high-speed networks.
- Ensure that second level pupils are equipped with the "*skills and competencies to embrace the challenges and opportunities of the digital age"* (DCENR 2013b)

Ireland is not alone in seeing investment in technology in education as critical, it is a key policy at EU level and amongst other initiatives funding of almost €150m has recently been agreed for Greece to implement digital education strategies in its school system with the intention of promoting "*new technologies, e-skills, digital literacy and equal opportunities in access to knowledge*" (European Commission 2014).

1.5 The impact of high-speed broadband in schools

Installing high-speed broadband in schools is only a first step, but it is viewed as a key *"enabler for eLearning and enhancing digital skills for school leavers*" (Rabbitte 2012). In the context of the ambitious plans for education reform envisioned by politicians and commentators such as Puttnam; and the expenditure committed to installing broadband in schools in order to (in part) facilitate such plans; the purpose of the following research is to assess the impact high-speed broadband provision is having in the schools that have already received it. The impact will be assessed by examining the potential changes brought about within the schools through the introduction of broadband. These may include:

1.5.1 Introduction of a device per student in classrooms

This is already occurring in many schools both internationally (Stern 2013) and in Ireland (Leonard 2013). The introduction of reliable broadband services should encourage

schools to consider this approach though who actually pays for the devices may become a matter for debate (Wreckler 2013).

1.5.2 Embedding of ICT in all subjects with instant access to online resources

This is envisioned in the National Digital Strategy (DCENR 2013a) and at EU level in the Digital Agenda for Europe (European Commission 2010). A radical restructuring of the school curriculum and the way it is delivered is reliant on high capacity reliable broadband access in the classroom. (In Ireland it is the PDST (formerly NCTE) that is responsible for training and promoting new teaching practices amongst existing teachers).

1.5.3 Remote learning (using video conferencing)

Allowing teachers to conduct lessons from remote locations, and students to access material from outside of the physical school campus has long been proposed as a use case for broadband in education. Whilst asynchronous learning may be possible on lower-speed consumer connections, real-time applications require capacity and reliability, and some of the schools on the pilot program have already started using their connections in this way (Kennedy 2011).

1.5.4 New approaches to teaching and assessment

The traditional method of assessing students using written exams based on fixed and somewhat inflexible subject curriculums may not be appropriate for current and future educational needs. The Junior Cert curriculum is currently being reformed with a view to introducing more interactive content, online assessment and reporting, and shorter courses; all of which envisage greater use of ICT resources and the internet for which reliable high-speed broadband will be essential (Sullivan 2012).

1.5.5 Improved efficiency, smarter administration, and financial savings in schools using technologies such as cloud computing and VOIP.

Schools, especially larger schools such as post-primaries, are effectively small businesses and in Ireland most have a high-degree of local management autonomy. Like any business they should be looking for opportunities to leverage ICT investment to improve the way their business is run and make financial savings. Many of the same technologies that are advantageous to small businesses are also applicable to schools and the provision of business-class broadband service should allow schools to take advantage of online technologies that were previously not practical.

1.6 What is the impact of high-speed broadband in Irish post-primary schools?

At a political level major claims are being made about the impact this investment will have, but with large sums of government money being invested over several years in the provision of this service to schools, it is necessary to question what effect this is having at the "coalface" of education, in the schools themselves.

In examining the impact of high-speed broadband questions to be considered include:

- What are schools doing differently as the result of the new broadband service?
- Is ICT in general, and the internet specifically, delivering educational value?
- Is access to high-speed broadband changing the way education is delivered?
- Which approaches are considered successful and which are not?

A number of differentiating factors will be taken into account

- Schools have had access to the broadband service for differing lengths of time.
- Schools have different levels of resources (both human and financial) available to them to leverage the use of ICT.
- Schools have different levels of expertise and support.

Chapter 2 of this paper examines the prior literature in several fields related to the use of ICT in schools and the wider educational world, and research on broadband in general. Chapter 3 outlines the research approach taken and chapter 4 analyses the data that was returned from the research. The final chapter contains closing remarks and suggestions for the direction of further research.

2 LITERATURE REVIEW.

2.1 Preamble

The introduction of high-speed broadband has the potential to impact how schools conduct their business in a number of different areas, so in reviewing the literature various strands of research were examined:

Research on the impact of new technologies within education was reviewed; both at school and university level where there has been a substantial amount of previous research, including a surprising number of studies that found negative outcomes. Within this section there are a number of papers that examine the dynamics within schools that influence whether new technologies are accepted and integrated successfully.

There is also a body of research on the effects of broadband in society as a whole, though some of this focuses on how broadband availability impacts on economic activity and real-estate prices which is not relevant here (Rampersad and Troshani 2013). These papers look at how broadband affects activities in areas such as health, education and direct interaction with government functions ("eGovernment") as well as some more general societal effects.

Further studies look into the use of broadband within the school environment and experiences from broadband implementation in other countries, though there appears to be less prior research in this area.

Finally there is a review of research into the usage of specific technologies within the classroom, and the focus here is on those technologies that are enabled by the availability of high-speed broadband such as videoconferencing and cloud services.

Literature searches were conducted using the TCD library Stella Search facility; the Web of Science, Ulrichsweb, Google Scholar and Synthesis databases, as well as general Google searches for non-academic references (newspapers, government reports etc.). Search terms included *"broadband" "ICT" "schools" "education" "cloud computing" "videoconferencing" "Ireland"* and various combinations thereof.

2.2 ICT in Education

There is a generally held perception that introducing new technologies in schools will invariably improve standards of education. This has been used by governments to justify investment decisions in this area (Machin et al. 2007).

There are also high expectations in schools of the potential benefits of ICT but these benefits are only partly dependent on the technology itself. The culture, training and

personnel within an individual school has a strong bearing on whether ICT is accepted and successfully integrated into the teaching environment:

"*the use of ICT for teaching and learning depends on the interlocking cultural, social, and organizational contexts in which they live and work*" (Somekh 2008 p450).

Studies that show a direct causal link between investment and higher student performance have been criticised for being overly simplistic and failing to take into account outside factors. More rigorous studies have found the effects to be mixed at best (Machin *et al.* 2007). The strong positive correlation between investment and educational outcome seen in Banerjee et al.'s (2007) study is an outlier in this respect, and as it was conducted in very poor Indian regions its relevance is questionable in assessing impacts in affluent western economies.

Their study uses differences in the levels of IT funding from region to region to differentiate the levels of performance and compensate for endogeneity. Local Education Authorities in India were allowed to bid for central government funding for ICT and this created winners and losers and a consequent disparity that could be correlated to educational outcomes. A positive effect from enhanced ICT investment was observed, particularly in English, but also in Science. Maths however showed no improvement.

In an Irish context the PDST has produced an e-Learning roadmap to assist schools in maximising the benefits they derive from investment in ICT. This framework adopts a whole-school approach to integration, and the EU and other national bodies have produced similar documents (European Commission 2003; Roberts 2007; PDST 2013).

The World Bank commissioned a study on a Columbian program that used computers donated by private business to teach languages in schools (Barrera-Osorio and Linden 2009). This study was large scale and randomised and it found that whilst the number of computers in each school was successfully increased via the program, test scores did not improve, and neither did other academic metrics such as time spent studying or students' attitudes to school.

The reason for this seems to have been a failure to integrate the new technology into the teaching of non-IT subjects. Students were taught how to use computers (which is beneficial in itself) but language and maths classes, which were the focus of the study, continued as before. Ultimately the program had little if any effect on test scores.

This "ghettoisation" of ICT into separate computer classes, or specifically into the STEM subjects (Science, Technology, Engineering, Maths), has been observed in the Irish system also, where the first appearance of computers within the curriculum came when they were added to the Leaving Cert maths syllabus as an optional module (the contents

of which were largely at the discretion of the school) (McGarr 2009). This is emblematic of a problem that has persisted throughout the history of ICT implementation in schools - a lack of vision as to how ICT can be used as tool for learning, rather than merely teaching students how to use computers as an end in itself.

The US introduced federal subsidies for schools wishing to purchase internet technology in 1996. It specifically focused on internet-connected hardware and services rather than ICT equipment in general. This program was worth over $2b by 2001 and poorer schools received a larger subsidy. Al Gore stated of the program "*Our nation has taken a great step forward in closing the gap between the information haves and the information have-nots*." Goolsbee and Guryan (2006) looked at public schools in California before and after this government investment. Whilst it did "bridge the digital divide" between richer and poorer schools, the educational outcomes were minimal. However these effects were measured by looking at SAT scores, and the curriculum for major exams tends to be relatively static and inevitably lags behind other developments in education. Changes in the performance of students may have taken place in ways that were not measured by the standardised exams. There is also the possibility that the new service was not being used, as the data only measured internet access, and not actual usage (Goolsbee and Guryan 2006).

Buettner (2006) looked at the integration of ICT in the Swiss education system in the context of a government report that found worryingly low levels of usage despite significant investment. Schools were found to go through a number of stages in their relationship with ICT, starting with it's use exclusively in programming and maths classes, and later the introduction of applications for word-processing and spreadsheets.

It is only with the subsequent stages of Integration, Communication and Cooperation that teachers see the value of ICT in the classroom beyond the narrow confines of teaching ICT itself. These later three stages could be approximated as: using the internet to access information; participating in the internet e.g. by creating webpages; and becoming "Digitally fluent" by interacting with the social web, understanding copyright, data-protection etc. The report indicated that few teachers and schools had progressed beyond the Integration stage and were at best passive users and not confident in utilising digital resource in delivering lessons.

Similar findings have been observed in Irish schools where studies in the 90s found that the majority of computer use was still for specifically ICT focused modules in subjects such as Business and Technology with "*little use of computer-aided learning*" evident, and that ICT remained the preserve of enthusiastic teachers, with no formal national policy in place (McGarr 2009).

In Switzerland a new approach was adopted, training selected teachers to integrate ICT into new pedagogical approaches with a view to having them subsequently train their colleagues ("train the trainer"). How successful this approach is in the long term has not yet been researched, and there is the danger that the first set of trainees will merely become pigeonholed as the "ICT person" in their respective schools. The program is dependent on their ability to enthuse and inspire their colleagues to "own" the new approach themselves (Buettner 2006).

Tearle (2003) examined a single English secondary school via interpretative case study to see how they had successfully implemented ICT within the curriculum whilst other schools had struggled with this task.

Three main findings emerged:

- External influences were found to be a strong factor - e.g. attaining Technology College status or competition entry - it wasn't that any individual external factor was significant rather that the school was involved in a large amount of external activities. Other external factors that were deemed to be "mandatory" such as the requirements of the National Curriculum were considered to have a negative influence on ICT adoption within the school.
- The school's ethos was found to be supportive and dynamic, with strong leadership, not just in the area of ICT. The school had a culture of trying to excel in its performance, and of promoting a collaborative culture amongst the faculty. The school also had pre-existing strong internal processes for the management of change, which facilitated the introduction of new ICT initiatives.
- The actual ICT implementation process. Key strands arising from specific events were identified in the research. These included preparation and planning, training and leadership. Implementation is described as "slow, staged and very focused."

A key strand identified in the study was the quality of people; that staff be

"*well motivated and caring, with strong leadership and high expectations of the school, (other) staff and students*" (Tearle 2003 p572)

Also of high importance was the appointment of an ICT coordinator. This is a role that appears frequently in the literature and is examined in more depth elsewhere in this review.

Other factors included resourcing and support. The school was felt to be well-resourced; though by some quantitative metrics (such as student:PC ratio) it was actually below average, the usage of ICT equipment was high within every subject and it wasn't limited to specific IT-related courses or computer labs.

Despite the positive message found in the research, the school did not appear to be doing anything particularly radical in the way it was integrating ICT into the delivery of the curriculum, and the researchers question the degree to which the sort of radical reform of education often promoted in reports and articles on the subject can be achieved in an environment where curriculum and assessment change occurs on very long cycles, and teaching staff received the bulk of their formal training in a more traditional environment (Tearle 2003).

This aspect is relevant in Ireland in relation to the reform of the Junior cycle, which is proposed to bring it in line with the current technological landscape. It could be argued that by the time the changes have been approved and implemented they will already be lagging behind external developments in ICT.

McGarr (2009), in a comprehensive chronological trawl through several decades of research, policy and curriculum documents and even trade union publications, reveals the difficulties in promoting and integrating ICT in the school classroom in an Irish context. He breaks down the development of ICT within Irish schools into three distinct phases - early explorations by enthusiasts within the system; the subsequent formalisation of ICT within schools; and the more recent integration of ICT into general education in response to the emergence of the information society.

Although the still extant "Computers in Education Society of Ireland" (CESI) was formed by enthusiastic teachers as far back as 1973, throughout the 1970s computer usage in schools remained a niche activity compared in one report to "the chess club or the debating society", and entirely dependent on the interests of staff members with no formal government support.

However from the mid-1980s onward a shift was observed in the usage of computers, away from the teaching of programming and maths towards the usage of ICT as a tool, with more general educational software and word processing. This was reflected in the policy adopted by the body responsible for the curriculum, which stated:

"Information technology should be developed on a cross-curricular basis, and be manifest in every subject. Information technology should be an essential element of the learning experience of all young people throughout the period of compulsory schooling". (CEB, 1987, as cited by (McGarr 2009).

The actual effect of this policy on the finalised curricula was minimal though. It was only in 1997 that a policy was finally put in place to ensure IT literacy amongst students and to encourage and support the integration of ICT into teaching. This initiative was an initial success but subsequent phases saw it lose momentum with allocated funding going

unused, and later studies found that whilst infrastructure had improved and more students had access to technology, it was still being use primarily to deliver "Computer Studies" style classes.

More investment in the last 10 years has seen the PC/Student ratio improve and broadband delivered to over 95% of all schools, but there remains a policy vacuum, with the level of integration of ICT within individual schools dependent on local factors such as school policy and ethos and the enthusiasm of individual teachers. It is suggested that future "initiatives for the promotion of ICT" should not be presented in such terms; rather these initiatives should be integrated into ongoing curriculum changes and professional development options for teachers in an attempt to normalise the use of ICT in all aspects of education delivery (McGarr 2009).

Judge (2013) takes a more recent example of ICT integration in Irish schools finding that, despite an increasing expectation that ICT should be implemented extensively in education, and a proliferation of new digital devices being marketed at, and adopted by schools and teachers; the reality is not matching the hype. New technology is not consistently being used effectively, and the factors determining this effectiveness are often local and dependent on organisational and cultural issues within the individual school.

A significant barrier for Irish schools has been underinvestment by successive governments. Despite the government publishing objectives for the integration of ICT, schools have been unable in the past to make progress in the area due to lack of resources being allocated by the Department of Education. Judge's research examines one of the measures put in place to address this gap; the HERMES project, which piloted the introduction of thin-client computing in a number of north Dublin schools with a view to providing a shared ICT service.

Some studies (ICT Ireland 2009) have shown that unreliability and poor support can act as a deterrent to uptake and usage of ICT services, and HERMES was designed to address these issues:

"The lure of a robust, stable and potentially trouble-free computer infrastructure was seen by all (the participating schools) as too good an opportunity to be missed" (Judge 2013).

Professional development courses were organised for teachers to assist them in integrating the service into their teaching; these were highly rated in the research for their "focus on pedagogy" and the reaction to the project as a whole was mostly positive with the data showing enthusiasm for the service. Projects of this type, though small scale,

can act as a blueprint for the introduction of new ICT services in the wider educational sector.

Teaching of ICT as an end in itself is no longer an appropriate strategy for schools. Whilst students must have the technical skills to operate new technologies increasingly they are acquiring these outside of the school environment. For teachers the challenge is to adopt a specific ICT-focused mindset regardless of what subjects they teach, in order to use the available technologies to facilitate better learning in their students. Technology is no longer "supplemental" it is now essential (Judge 2013).

There is some conflict between survey data, which shows teachers claiming to be using technology to deliver content in innovative ways, and more observational research, which shows this not to be the case (Ertmer and Ottenbreit-Leftwich 2010).

In order to maximise the effectiveness of their technology use, teachers must learn new skills in areas such as planning, implementation and evaluation. It is also more important for teachers to be confident in their use of new technologies than it is for them to be highly skilled (though it could be argued that the former would derive from the latter).

As seen in other papers, the culture of the school is highly significant in determining the success of individual teachers in adopting new or innovative technical solutions - teachers are not "free-agents" and must operate in a wider organisational structure. This is particularly true of novice teachers - whilst they may (by virtue of youth and recent exposure to current pedagogical practise) be the most likely to adopt innovative new methods, they are also likely to feel pressure from more experienced colleagues to adopt the prevailing practices of the school (Windschitl and Sahl 2002).

What is required is a new definition of "effective teaching" that leverages the ICT resources available in a meaningful way. Teachers have to feel this definition relates to their environment and should have access to relevant examples or role models so they see what it looks like in practice.

Afshari *et al.* (2009) examined the factors that affect the extent to which individual teachers used ICT within the classroom. ICT can be: a) a subject to be studied in itself; b) one aspect of a particular subject such as maths or engineering; or c) a tool for the delivery of knowledge and the enhancement of learning.

They classified the factors affecting ICT integration as either manipulative or non-manipulative; non-manipulative factors are those outside of the school's control; e.g. the age of the teacher and their ICT experience, government policy and outside support factors. Manipulative factors by contrast are within the control of the school; the training available for teachers, fostering a supportive environment and a strategic focus on the use

of ICT by management. In common with other studies they found that younger teachers more likely to use ICT. In relation to teacher training, offering ICT as a separate module was deemed less successful than integrating ICT into the general delivery of the training.

A key actor in driving the uptake of new technology in the school environment is the "ICT coordinator". Kwok-wing Lai and Pratt (2004) found ICT coordinators tend to be from the management, ICT or Maths faculties and are generally knowledgeable and enthusiastic about ICT. Self taught and responsible for their own up-skilling they have influence in planning and formulating policy and teaching plans for their school, usually alongside either the principal and/or a committee. As key decision makers in the purchase of new equipment and software, their role is equal parts technical and curriculum support.

However in most schools it is not a dedicated roll and little or no time is formally allocated to do this work. A lack of recognition of the commitment required and the importance of the role is a common complaint. Many ICT coordinators find too much time is given over to technical support at the cost of strategic work, and teachers in general feel that they do not get enough curriculum support for ICT, and that the integration of ICT into the curriculum is progressing too slowly (Kwok-wing Lai and Pratt 2004).

2.3 The impact of broadband on society

A number of countries, including Ireland (DCENR 2012), are introducing national broadband schemes aimed at increasing the speeds available to the general population to meet demand for new high-bandwidth services such as streaming video and cloud storage. A lot of money is being spent on these programs, but there hasn't been much research on the social impact of providing such services. Previous research such as Hill *et al.* (2011) has focused on access & adoption rather than impact, looking at issues such as coverage, demographics and other quantitative measures. Where there is research on impact, it tends to focus on economic rather than social impact. There is a suggestion that adoption may be demand-constrained rather than supply-constrained.

Rampersad and Troshani (2013) address this gap by creating a framework for the assessment of this social impact, which they define as

"*changes to people's way of life, their culture, community, political systems, their environment, health and well-being, their personal and property rights and their fears and aspirations*." (p542)

They find existing literature has focused on themes of healthcare, education and community development, as these are the areas often cited by authorities when implementing broadband schemes. In the area of healthcare claimed benefits include remote diagnosis, transfer of large files such as radiology, and savings in time and travel

for patients. In education, extending the availability and quality of opportunities for remote users is one of the use-cases examined; though this is arguably more relevant in Australia where the study was carried out, due to the large distances between settlements. Also studied is the impact on the community via improved engagement with the aged, disabled and socially excluded and the development of online communities of interest and social networks.

Lack of previous data is blamed on the fast pace of developments in the area. A local example of this is the previous Irish National Broadband Scheme, launched in 2008 but regarded as technically out-of-date almost from the start (Ryan 2013) and subsequently superseded. Drawing from an EU report stating the "*social impact of ICT is still basically unexplored*" (EU 2009) the researchers emphasise the importance of looking at the impact of ICT on the "life of citizens".

Some writers (e.g. Firth and Mellor (2005)) question the social benefits claimed for broadband, and suggest that it may actually lead to a decrease in standards in area such as health and education by distancing users from professionals and encouraging the use of poor quality materials. The research therefore proposes a framework to assess the social impact of broadband based on case studies of users of Australia's National Broadband Network, followed by thematic analysis of interviews in the context of existing literature. The results are described as exploratory and caveated as "possibly of limited generalisability" which is a fair assessment as it addresses only a small number of questions, particularly in the education section, though in mitigation education is not the primary focus of the research. There is no research into possible political or cultural impacts and it is not clear how the resultant framework can be reused by future researchers or policymakers in other contexts (Rampersad and Troshani 2013).

Firth and Mellor (2005) identify a lack of clarity in the existing research on broadband and its effects on the individual and society, whilst finding economic impacts are often overstated. Some research papers and government reports (e.g. the current National Broadband Plan for Ireland (DCENR 2012)) have posited potential benefits from the rollout of broadband such as improved educational opportunities, jobs, new business models, and better governance, and this has led to a consensus emerging that government intervention to accelerate the rollout of broadband (either through direct investment or market intervention) is justified. However some of these are recycled claims from earlier research into the general (narrowband) internet. Prior to embarking on large-scale programs to rollout expensive broadband networks, governments need to analyse "the panoply of possible outcomes." both positive and negative based on the research available.

2.4 Broadband in education

The potential of high-speed networks to facilitate new modes of education has long been recognized, with broadband both at home and in the institution proposed to "*liberate education from time, place and space restrictions*" (Zahariadis and Voliotis 2003 p67) through the development of distance learning both synchronous and asynchronous The increasing speed and ubiquity of broadband has facilitated a move towards online courses ("MOOC"s) that some have suggested threatens the future of traditional third-level education (Vardi 2012).

Underwood *et al.'s* (2005) research on behalf of BECTA assessed the impact broadband was having in English schools (this was a follow up to an earlier study). They found there was good evidence that the quality and quantity of activities enabled by the introduction of broadband was related to the confidence that the teachers had in the reliability and capacity of the connection. A more reliable connection that allowed for simultaneous use by multiple users facilitated a greater embedding of internet usage into everyday classroom activities. Conversely where the capacity of the connection was insufficient (as was found to be the case particularly in some secondary schools) this had a negative impact on adoption of internet-based classroom activities.

Broadband and ICT were allowing schools to adopt new ways of teaching and working. As well as seeing increased use of ICT outside of the traditional "core subjects" of maths and science (and of course Computer Studies), the new technologies were allowing increased collaboration between schools; more electronic production and storage of students work; and more opportunity to break out of the traditional school milieu by students and teachers working at home within a single virtual space:

"*young people and their teachers are re-organising their work patterns as they manage their activities electronically rather than in physical space*" (Underwood *et al.* 2005 p13).

In common with other, more general research into the adoption of ICT within schools they also found that management commitment and institutional culture were key to the uptake of new technologies with the school as a whole.

Belo *et al.'s* (2010) study of the use of broadband in Portuguese schools showed detrimental effects on student grades, and a converse improvement in performance where certain websites such as YouTube were blocked. Researchers recorded actual usage rather than just noting the presence of a broadband connection in the school - this is in contrast to the general body of research in the area, which has tended to focus on the impact of investment.

Whereas the student/teacher ratio has been shown to have a consistent effect on educational outcomes the impact of ICT can be variable and outside factors, often unobserved, can affect the findings.

"Without proper monitoring and control, broadband access in schools may be more harmful than helpful" (Belo *et al.* 2010 p5).

Some studies have attempted to use exogeneity in technology application to compare to differences in results, such as schools receiving access to new technologies at differing rates, or different regions within the same country operating differing funding models for ICT. Many of the studies have shown a negative impact, somewhat contrary to the generally held view that investment in ICT for education is a universally good idea. As in Ireland the policies governing internet access differed from school to school - despite being state-funded schools in Ireland are largely autonomous organisations.

Whilst the introduction of broadband in schools provides new opportunities for delivering the syllabus in a more interactive and interesting way, access to additional distractions on the internet may offset any improvements in performance that result (Belo *et al.* 2010).

2.5 Broadband-enabled services

2.5.1 Video

A 2005 BECTA report (Underwood *et al.* 2005) found schools were making use of broadband-dependent services such as video-conferencing and remote learning. Comber and Lawson (2013) later carried out more in depth research into videoconferencing. A previous study (Comber *et al.* 2004) had found generally positive results from a government-sponsored program to put video-conferencing equipment in schools. The equipment enabled inter-school and intercultural activities as well as remote lessons provided by outside experts, and the study found improvements in behaviour and motivation to be among the benefits.

The later follow-up research however found that video-conferencing had become something of a forgotten technology, both in some of the schools studied and also in ICT policy formulation for schools. This was partly because the video-conferencing technology that had been put into the schools had been superseded by later developments in internet video services.

Video-conferencing as a technology predates the internet and older implementations use dedicated hardware that supports both internet and non-internet (ISDN) interconnection. These dedicated video-conferencing devices tend to be large and non-portable so schools were restricted to using them in specific "video-conferencing rooms". This lack of flexibility

in comparison to recent development in the area (Skype and similar services that can run on any internet-connected device) resulted in the equipment falling into disuse in many of the schools.

This can be viewed as a failure to "mainstream" the technology, an issue that appears repeatedly in the literature. ICT is often seen as a niche subject, to be taught as an end in itself or in the context of related subjects such as maths and science, rather than integrated as a tool for the delivery of the curricula as a whole. Isolating the video-conferencing service in a particular room had a similar effect to restricting computer use to a single "computer lab" with classes allocated a set time for access each week.

This over-specialisation of the technology was also apparent from a staffing perspective. In most schools a single member of the faculty was viewed as the "expert" or "owner" of the video-conferencing service and it was their enthusiasm that drove usage amongst the rest of the staff. This shows the importance of key personnel in the school at management and co-ordination level both understanding the technology, and championing and pushing its use amongst the other teachers. The loss of these personnel in some schools led to a rapid decline in the use of the technology. This is a common feature in much research into the use of ICT in schools e.g. early use of computers in Irish education was mostly driven by enthusiastic/hobbyist teachers, generally maths teachers, and the extent to which the technology was pushed within individual school was dependent on the presences of such enthusiasts (McGarr 2009).

The research confirms three key elements of sustainability of technology adoption: agency (the active commitment of key personnel), culture (the learning ethos of the school) and structure (the wide policy frameworks in which school initiatives operate).

This does not negate the benefits of using two-way video communications in a classroom context, and the benefits perceived in the earlier study remain valid. However the schools involved in the study found that issues, including lack of access to reliable high-speed broadband prevented them from replacing the older technology with newer classroom-based solutions (Comber and Lawson 2013).

Use of video-conferencing for the remote delivery of lectures is a common scenario that is suggested in the literature. Smyth (2005) developed a framework that looks at different pedagogical approaches and examines their suitability for application via video-conferencing, referencing a number of examples as practiced in Australian 3rd-level institutions for distance education. These include:

- One-to-many (the traditional class/lecture)
- One-to-one (mentoring and supervision)

- Many-to-many (project group meetings and teamwork).

Pedagogy, the science of "how we teach" is constantly evolving and the best teachers themselves are continuously developing their methods, so video-conferencing can be seen an additional tool to enable them to enhance the learning outcomes for their students (provided this is underpinned by sound pedagogy). The introduction of high-speed broadband overcomes many of the drawbacks of early experiments in using video-conferencing in schools and several Irish schools are using the service to deliver and receive classes via remote-video link (DCENR 2013).

2.5.2 Tablets

Pegrum *et al.'s* (2013) study is of particular relevance to Ireland as many post-primary schools are now adopting a device per student strategy using laptops or, increasingly, handheld tablets such as iPads (Leonard 2013). For the expense incurred in doing this to be justified schools must use these devices as more than just glorified e-readers.

Increasing use of mobile devices is seen as facilitating a move towards "ubiquitous learning" where students have constant access to information with a high degree of contextual relevance. This form of learning is best achieved with a 1:1 device to student ratio.

"With the mobile technologies at hand, students can learn seamlessly – both in classroom and out of classroom, both in school time and after school time" (Pegrum *et al.* 2013 p68).

In this context individual tablets are seen as a "game-changer" with a wide range of educational tools and applications available. It is understandable that schools are keen to adopt this new model, despite the guidelines for adoption still being under development and some schools may have found that the technology has not lived up to the marketing hype (Calnan 2013).

Introducing mobile devices has been found to increase motivation, communication and better teaching processes. More quantitative studies (Hwang *et al.* 2011) have found positive educational outcomes in areas such as languages and maths.

It was found that the way in which schools used the mobile devices was more important than the devices and apps themselves. Respondents felt that they did represent a shift in educational model away from traditional teacher-led classes to a more collaborative structure. However there was also concern that existing methods of assessment would not be able to keep pace with changes in the classroom (a problem that is to the forefront of current debate about Junior cert reform in Ireland (Donnelly 2014)). Students would still have to sit a written exam at the end of the curriculum cycle that was largely a test of

memory - in this context the mobile devices could be seen as a distraction from necessary studies (Pegrum *et al.* 2013).

2.5.3 Cloud services

Increased use of cloud-based services is another potential benefit for schools receiving high-speed broadband. Research in this area has tended to look at the benefits for the 3rd-level sector, but these may be applicable also to schools. Early software-as-a-service (SaaS) type applications appeared in the 1990s but were not widely adopted due to lack of bandwidth and the cost of accessing the internet.

Sultan (2010) identifies three types of cloud service:

- Infrastructure as a service (IaaS): incorporating virtual servers, cloud storage
- Platform as a Service (PaaS): hosted databases, middleware and web servers
- Software as a Service (SaaS): online applications, CRM, email, documents etc.

All offer reduced hardware and power costs over local hosting and some of the technical knowledge requirements are removed (as support is supplied by the service provider). Amazon offers 2 main cloud services - EC2 (virtual servers and PaaS) and S3 (storage). Google, IBM and Microsoft offer other services.

Rapid rate of technology change puts a lot of pressure on educational institutions both from a budgetary and human resource perspective. Schools in particular do not have the resources to update their hardware and software on a sufficiently regular basis to keep up with the changes in the technological landscape, and many schools are using outdated operating systems, hardware and software.

Universities are taking advantage of cloud services to allow them to spin up large quantities of virtual servers for specific course and research requirements – e.g. UCLA have partnered with AWS (UCLA 2014). These are cases where the technology is being used to achieve objectives that would have been technically unfeasible before, rather than purely to save costs.

In Ireland DIT have been using cloud compute services to analyse big data from astronomical surveys (Doyle 2013). Google Apps and MS365 are used by a number of Irish 3rd level institutions. In particular Email which has traditionally been seen as a major cost centre by university IT departments is increasingly being moved off campus onto cloud services such as Gmail, provided at zero cost by Google (Kennedy 2007).

At a schools level (but not in Ireland) Pike County schools (a district in Kentucky with 27 schools and 14000 users) used cloud computing infrastructure to replace its outdated IT systems in 2008. At that stage many schools were still running Windows 98 and

hardware was unreliable. Also the geographically distributed nature of the organisation made is difficult to maintain and manage the IT infrastructure estate.

In collaboration with IBM the district moved to a cloud-based Desktop as a Service virtual infrastructure - this allowed them to access up to date applications and services on machines that were otherwise life-expired, as well as centralising management and providing a more homogenous user experience across all the schools (IBM 2010).

Mathew (2012) outlines a number of potential drawbacks to the introduction of cloud technologies in education, specifically concerns about security of data, privacy and the reliability of the service. However this is balanced by clear benefits to users, who can access files from anywhere, share content easily and spend less time dealing with software licenses and creating and managing backups.

2.6 Summary

The main findings of this review of the literature can be summarised as follows:

- ICT has traditionally been concentrated into areas of the curriculum related to technical subjects. In order to effectively change the way education is delivered it needs to be integrated into all aspects of the school curriculum.
- The successful integration of ICT into education is highly dependent on a supportive culture within the individual school that encourages teachers to use technology in new ways. A further key dependency is the presence of an ICT coordinator who is a strategic leader rather than just a technical fixer.
- Both of these previous factors will have a strong influence on whether programs of investment in schools ICT are successful. Merely committing money to a program of this type is not sufficient and previous investments have often not had the positive outcomes envisioned.
- Providing broadband to schools can have positive educational outcomes, but it too is dependent on internal school dynamics that will determine whether internet usage is fully integrated and effectively utilized in classes. Lack of reliable broadband is a severely inhibiting factor for schools wishing to incorporate the internet into teaching.
- Cloud services and individual learning devices offer opportunities for schools to change how classes are delivered and ICT infrastructure is provisioned. However video-conferencing remains something of a niche technology in schools, and is yet to achieve widespread adoption.

3 RESEARCH APPROACH

3.1 Preamble

In considering which research approach to take on this topic a number of different options were considered, based on reading of previous research for the literature review and background information on the project and the general use of ICT in education.

The purpose of the research is to assess the "impact" of providing high-speed internet access to schools, but the word impact itself is open to various interpretations. The aim is to take a broad interpretation in assessing whether the introduction of such a service affects areas such as the method of delivery of classes, the use of new technologies within the school environment, and whether there is a improvement in educational outcomes, either measurable (through exam results) or perceived (via the opinions of the educators).

3.2 Approach

The main question being asked - "what is the impact" of this technology change - lends itself to an inductive approach. If schools are being provided with a new technology, or even an improved version of a service they already had, a narrative is being constructed around the changes that are created in the technological and pedagogical environment.

Some of the sub-questions could be considered more deductive in scope however; there is an implication (within the policy objectives and media publicity around the project) that providing high-speed broadband drives the use of ICT in the classroom and changes the way that subject material is presented. There is also the belief, somewhat contradicted within the literature review, that improved technology within the classroom improves academic outcomes and exam results. Demonstrating this empirically is beyond the scope of this paper but asking the opinion of those who are at the interface between the technology and the students has the potential to provide useful subjective data.

The question can also be considered to be open to both an exploratory approach - ascertaining what is happening as a result of this change in the school environment; and an explanatory approach - what specific factors are contributing to these changes (Saunders 2009).

A strictly quantitative correlation of the results of standardised testing against the availability and use of high-speed broadband was one approach considered (this would be similar to the research undertaken by Belo *et al.* (2010) in Portugal). However it was considered impractical as whilst it may be possible to obtain firm data (e.g. from the HEAnet monitoring systems) of the usage patterns of individual schools - which

applications are in use, how much data is consumed relative to the size of the student population etc.; obtaining the data on the exam results in the time available was not possible. Also the relatively recent time frame in which most schools have received the service would make it difficult to draw any firm correlative conclusions.

With the availability of reliable high-speed broadband bedded-in within the curriculum it might also be possible to compare the approaches taken by different schools with regards to the use of different technologies with the classroom; perhaps by comparing the experience of schools using tablets or other individual computing devices, versus those schools using shared devices or computer labs.

Taking the view of an outsider looking into the classroom to observe the effects on classes and the school as a whole, it was considered that the best approach was to ask those on the inside their opinions on the broadband service and it's impact.

Interviewing individual ICT coordinators and principals was considered but this would have provided quite a narrow view, and with the research window coinciding with the period of the school year when teachers and students are preparing for state exams it might be difficult to get the subjects to commit the time (conducting one or more case-studies was discounted for similar reasons).

A survey of those using the new service was ultimately the most practical method of obtaining a wide-ranging view on the range of questions raised by the topic. This method had it's own drawbacks – in seeking the permission of the Department of Education to carry out the research it was stated that response rate from schools to non-official surveys may be poor. In addition the people who were the intended targets of the survey may have been surveyed previously about aspects of the project (and probably receive a number of requests each year to respond to surveys on various other matters). However the advantages of being able to gather information from a wide cross-section of the schools in a relatively short period of time was significant, particularly given the time constraints affecting both the subjects and the research itself.

3.3 Philosophy

Although the implementation of a new technology, and the consequent availability of hard data may lend itself in some circumstances to a positivist and experimental approach; this research topic is more influenced by the actions of the end-users of that technology, and the organisational context (the school) in which they interact.

Research which deals primarily with people and information in a world of change, competition and fluid communications technology should take into account and allow for an understanding of human behaviour (Burke 2007, as cited by Saunders 2009)

Orlikowski and Baroudi (1991) argued that:

*"a single research perspective for studying information systems phenomena is unnecessarily restrictive and that much can be gained if a plurality of research perspectives" (*is used to examine the interaction of IS, people and organisations.) (Orlikowski and Baroudi 1991 p1)

They assert that whilst the researcher must be conscious of the "research traditions" within their field they must also be open to the possibilities of other practices and approaches. At the time their review a positivist approach was dominant (95% of the papers they examined had a positivist slant). They examine the merits of researching information systems topics from both an interpretative and a critical philosophy; with the former contributing an understanding that the "social process involves getting inside the world of those generating it"; of recognising that technology does not exist in isolation but must be studied in the context of how people use it, interacting with it and each other; whilst the critical tradition locates the research subject within its social and historical context.

Badley (2003) argues against a "false dualism" that divides positivist and constructivist researchers, and the belief (particularly from a political standpoint) that scientific research can always provide some form of evidence-based "best practice"; when this may not take sufficient account of the level of uncertainty inherent in research areas with a strong human element such as education and the social sciences.

A pragmatic approach does not necessarily seek the absolute truth but aims to find better answers using the most suitable tools available from any research philosophy. This is not so much a philosophy as a working perspective, one that is "appropriately fuzzy" and suited to research in the field of education, as seeking certainty through scientific methods is not practical, "all it can provide is possible lines of action."

This approach has practical application for teachers as well, who should not see themselves as technicians or the end-result of educational research, but as participants in a continuous process of research within the classroom. (Badley 2003)

In seeking the opinions of the "social actors" within the school milieu, a pragmatic and subjective view is being taken, as it has been shown consistently in the literature that the culture of the organisation has a strong bearing on the uptake of new technologies, and this culture is mostly driven by the people within the organisation (and in the case of schools, as found repeatedly in the literature review, often just one person).

This analysis of the interaction of people (teachers/students) with each other, and with the technology as end-users and innovators, suggests a pragmatic philosophy of research is

appropriate to obtain a full picture of the impact of the broadband service. Whilst the methodology (survey) eventually chosen is largely based on quantitative analysis it is intended to leave scope within the questions for some qualitative data in order to provide more insight into the interactions of the subjects.

3.4 Design

Galesic and Bosnjak's (2009) paper correlating questionnaire length with participation and response quality found that (unsurprisingly) longer questionnaires produce a poorer response rate; so in designing the survey it was considered important to keep the overall length reasonably short (aiming for around 10 minutes completion time, a timeframe that was stated in the invitation email and the preamble to the survey), and the individual questions as simple as possible, to avoid the likelihood of participants getting bored and closing out before submitting.

In particular the use of large matrices of multiple choice opinion questions was avoided as these can be tedious to answer and prior literature suggests they are off-putting for respondents:

"Questions asked later in the questionnaire bearing the risk of producing lower quality data, especially if they are in open format or in long grids" (Galesic and Bosnjak 2009 p358).

Survey questions were grouped into subjects based on the main issues that were revealed by the literature review:

- The environment and culture of ICT use within the school
- The educational impact of internet usage within the classroom
- The use of internet-enabled new technologies

Surveys containing some "open" questions can be both exploratory and descriptive (Saunders 2009), so the opportunity for descriptive answers was provided in a number of place within the survey. This allowed some input from the end-users "in their own words" and the gathering of data on the use of the service outside of the boundaries of the set questions. A free-text narrative option was also included at the end of the questionnaire.

Baruch and Holtom (2008) found that electronic surveys received a response rate equal to or greater than those using paper methods but there is a general difficulty in getting research subjects to respond to questionnaires particularly if they consider them inessential. Response rates to questionnaires in organisational research have declined considerably over the years. Principals and teachers are likely to be the occasional target for surveys on a number of topics and may have "survey-fatigue", but the main reason for

non-response is likely to be that they are simply too busy (more so in the latter half of the school year).

The use of incentives has been found to be ineffective and the use of reminders to correlate with a lower response rate (though it is speculated that surveys with a low initial response are probably more likely to send out reminders). One reminder to participants was sent out for this survey, which did generate additional responses.

In their recommendations they recommend that the following issues be addressed with regards to response rates and these are outlined in the next section:

Information about the sample

- *How many people was the questionnaire sent to?*
- *How was it distributed? (e.g. traditional mail, internal mail, email, web, in person)*
- *Was it sent to people who volunteered for the study (prior consent)?*

Questionnaires returned

- *How many questionnaires were returned?*
- *Of those that were returned, how many were usable?*
- *Was there a typical reason for receiving unusable questionnaires? If so, explain.*

(Baruch and Holtom 2008 p1155)

3.5 Practical Matters

Subsequent to conducting literature review, research design was conducted in March 2014, with ethical approval sought and received (after some revisions) in April. As the research involved contacting schools, reassurances were given that no contact with the students themselves was planned.

The survey population was all schools that have received the 100Mb service prior to the current academic year. This was a total of 280 schools. Schools that have received the service within the current academic year were not included within the research population as it was felt they would not have had time to assess the impact of the technology (and some of them may still have been in the process of installing new networks etc. to utilise it fully).

All schools within that population group were contacted by email to complete the survey. The email was directed in most cases to the principal or the designated school contact nominated for the broadband project (contact information having been provided by the Department of Education).

The survey itself was hosted online (at freeonlinesurveys.com) and the number of responses received was 46 (16% response rate). A number of other respondents clicked through the survey without selecting any questions resulting in blank responses, which were removed, but incomplete surveys (i.e. where some but not all questions were answered) are included in the data analysis. Most responses were received within 2 weeks of the soliciting email, with a small additional number received after a reminder email was sent.

As this was effectively a self-selecting sample, there is a risk of some voluntary response bias in the results towards those users who have a more active interest in ICT use in the classroom (and consequently in answering questions on this topic).

4 FINDINGS AND ANALYSIS

4.1 Preamble

The survey of ICT coordinators was divided into 6 sections of multiple-choice questions, with a further section at the end for respondents to provide written feedback on the broadband service and related matters.

Survey Sections:

- ICT Environment
- ICT Policy
- Controlling Internet Access
- Educational Impact
- Broadband Usage
- Technology Usage

Initial statistical analysis was provided by the survey website in the form of simple tables and graphs. A spreadsheet of responses was also produced from the website and imported into the SPSS statistics package, where it was recoded as appropriate and more complex tables, graphs and statistical analysis (particularly of multiple choice questions, and cross tabulation of responses) were produced.

4.2 ICT Environment

Nearly all schools are using both desktops and laptop computers, with a majority of schools also using tablets such as iPads and Android devices. Use of eReaders such as the Kindle is very low (less than 10% of schools), with a handful of schools also using other devices such as smartphones and iPods.

Nearly three-quarters of schools continue to operate under the more traditional fixed computer-lab model for classes involving ICT. Previous surveys have shown this to be the most common scenario (NCTE 2006) but it is perhaps surprising that it is still so prevalent. An increase in the use of individual devices within the classroom is something that might be expected as schools push internet access (via Wi-Fi) into the teaching areas within the school but this doesn't seem to have happened yet in many of the schools surveyed.

Although 75% of respondents do have a Wi-Fi network within the school it is surprising that as many as 25% do not. To fully utilise high-speed broadband for the delivery of lessons, availability of Wi-Fi would appear to be a pre-requisite, and schools that do not have this facility in place are severely restricted in introducing individualised devices such

as tablets (a tablet without internet access is severely crippled in it's capabilities). Indeed all of the schools that stated they are using tablets also stated that they have an internal WiFi network, suggesting that the 25% of schools without WiFi are unable to introduce tablets until such a service is in place:

Table 4-1 – Wi-FI / Tablet use correlation

		Using Tablets	
		Not ticked	Yes
Does the school have a Wi-Fi network?	Yes	45.0%	100.0%
	No	55.0%	0.0%
	Total	100.0%	100.0%

4.3 ICT Policy

Every school that responded has a formal policy in place for the use of internet via the school's own network. The majority of schools also have someone specifically designated for the ICT coordinator role. For the schools that do not have anyone fulfilling this function, it must be questioned how ICT policy is formulated. The literature suggests it is detrimental to the effective use of ICT in the school environment if some person or body is not specifically tasked with providing policy and direction to the schools ICT activities.

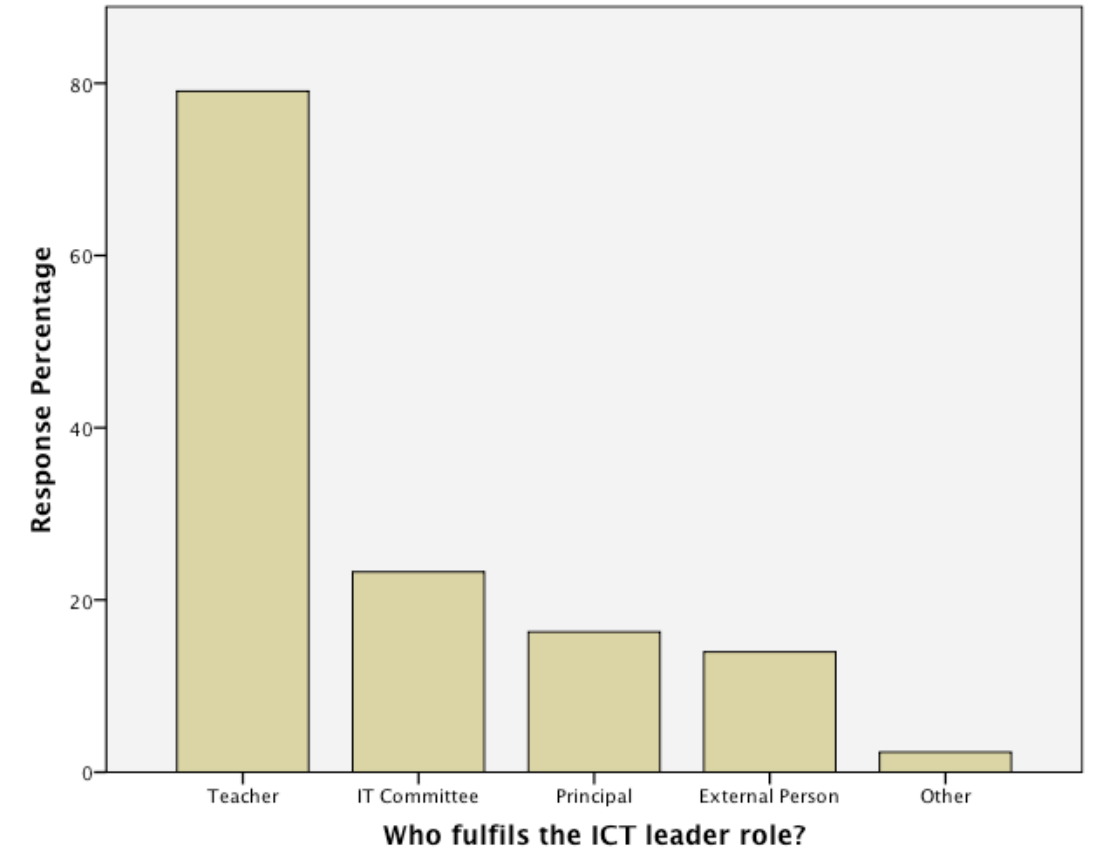

Figure 4-1 ICT Leader Role

With regards to who fulfills this role, this was offered as a multiple-choice question where more than one answer was permitted, as the role may be shared across various people in some schools. In common with the literature, the most frequent scenario in the schools that responded was for an individual teacher to act as ICT coordinator

4.4 Educational Impact

Schools were asked if they felt they were being given sufficient guidance to maximise the use of the broadband service. This is a subject that is addressed in a number of places in the literature, as well as by digital education activists such as Puttnam and Evers. It is not sufficient to merely provide the technological infrastructure; there must be measures in place to ensure that the technology is effecting a change in pedagogical practise.

In many schools this may be driven by one or two enthusiastic members of staff, but this is an ad-hoc approach that does not scale. In Ireland the PDST (formerly NCTE) runs workshops and provides training material to teachers on the use of ICT in the classroom, but the survey data shows that teachers do not feel that this is enough, with only 27% of respondents agreeing that sufficient training is being provided to them:

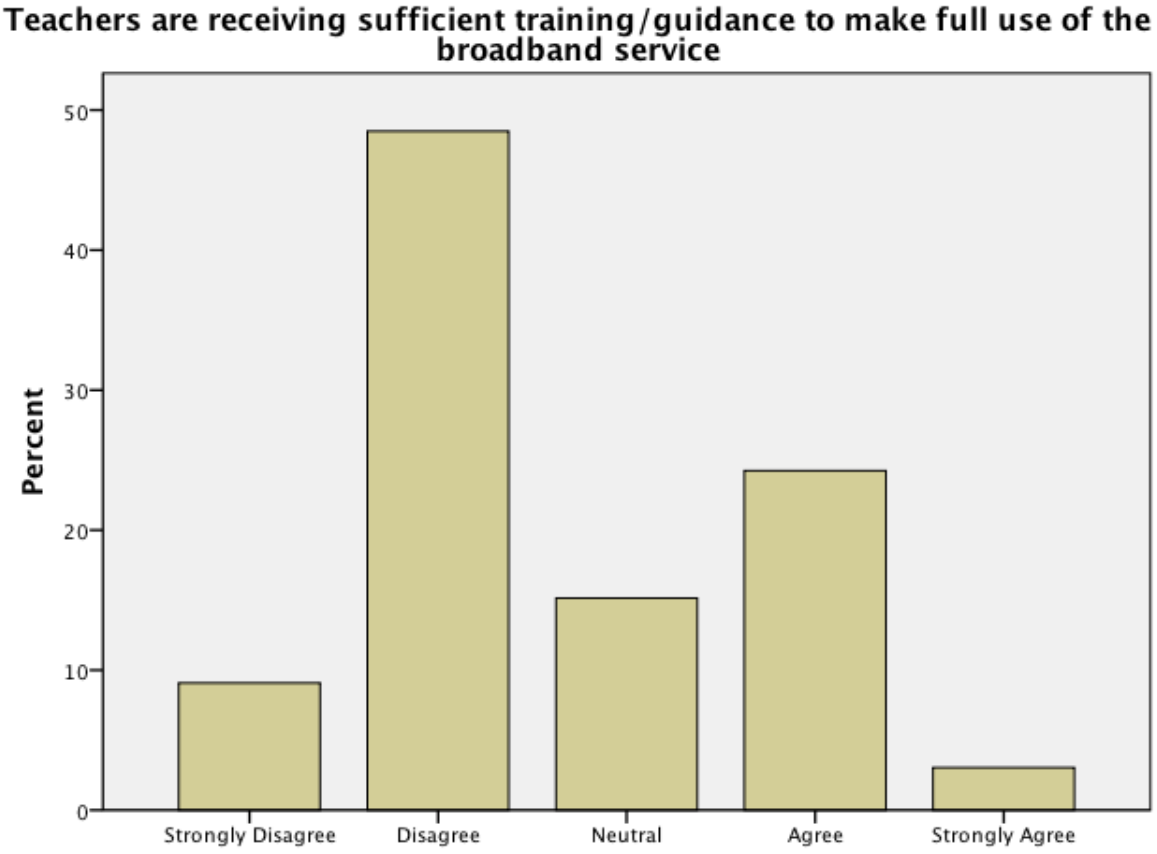

Figure 4-2 Training & Guidance

On the question of whether use of the internet in classes actually improves exam outcomes, the opinion of the respondents as educators was being sought, so this data reflects a subjective view. Here there does appear to be a belief that using the internet in class has a positive educational effect (at least in the context of standardised testing). 72% of respondents answered this question and 60% of those agreed or strongly agreed. There is a likelihood of some bias here as the respondents are "ICT coordinators" (or equivalent) and a survey of the larger teaching population might reveal a less positive association.

A more rigorous test of this hypothesis would require statistical analysis of actual state exam results against usage of the internet in classes over a reasonably wide sample size (and possibly with a longitudinal element as well) but it may be difficult to achieve an accurate measure of the latter variable. Belo *et al.* (2010) attempted a purely quantitative comparison of results against data usage and distance from the broadband exchange; but both of those measures of internet usage are problematic (as discussed in the literature review).

The other question in this section asked if the curriculum had adapted to account for the use of ICT in the classroom, a topical question given the current debate over Junior Cycle reform. This elicited is a surprisingly positive result, given the difficulties outlined in some of the prior literature in adapting subject curricula to new methods of digital learning. 58% of responses agreed or strongly agreed that the overall curriculum was adapting to the use of technology in the classroom.

4.5 Controlling Internet Access

This section examined what restrictions are in place to control access by students to the network, as well as more specifically to social networking sites, which have been implicated in online bullying and other disruptive behaviour.

The data reveals that "Bring your own device (BYOD)" is not yet a popular model in Irish schools and students are generally not permitted to connect their personal devices to the network. The findings here are in line with those in the recent "Net Children Go Mobile" report (Mascheroni and Ólafsson 2014) which found that use of mobile internet devices is highly moderated in Ireland, both inside and outside of schools, when compared to other European countries. It is more likely that where individual devices are available they are provided directly by the school, but there are also schools where students buy a standardised device that that, whilst considered their own property, is administered by the school's own IT service (Leonard 2013).

The majority of schools have restrictions in place on internet activity during classes. In reality the 100Mb service is itself restricted (there is a centralised filtering system in place controlling access to certain categories of websites and applications) so there is likely to be some additional split here between those schools that have their own internal systems in place to restrict access, and those that are relying purely on the centralised system.

In the "Other" category which permitted a more descriptive response to this question, one respondent stated that there was a system in place "but staff don't use it" whilst another school outlined a system where tutors could block access at their discretion for specific classes.

Slightly less than half of schools do allow access to the internet outside of regular classes; as a larger majority of schools do not permit BYOD style access it is assumed that some of the schools that permit access outside of classes are doing so by allowing access to computer labs for after-school study or similar, and this is likely to be highly moderated access.

Use of social networking services amongst teenagers is a area of concern for a lot of schools (and indeed parents) with cyber-bullying being a particular worry and sites such

as Facebook and Ask.fm have been implicated in some incidents of teen suicide (Arkell 2013; Harkin 2013). Nearly all respondents answered this question and less than 5% of the schools allow access to Social Networking services via the school network.

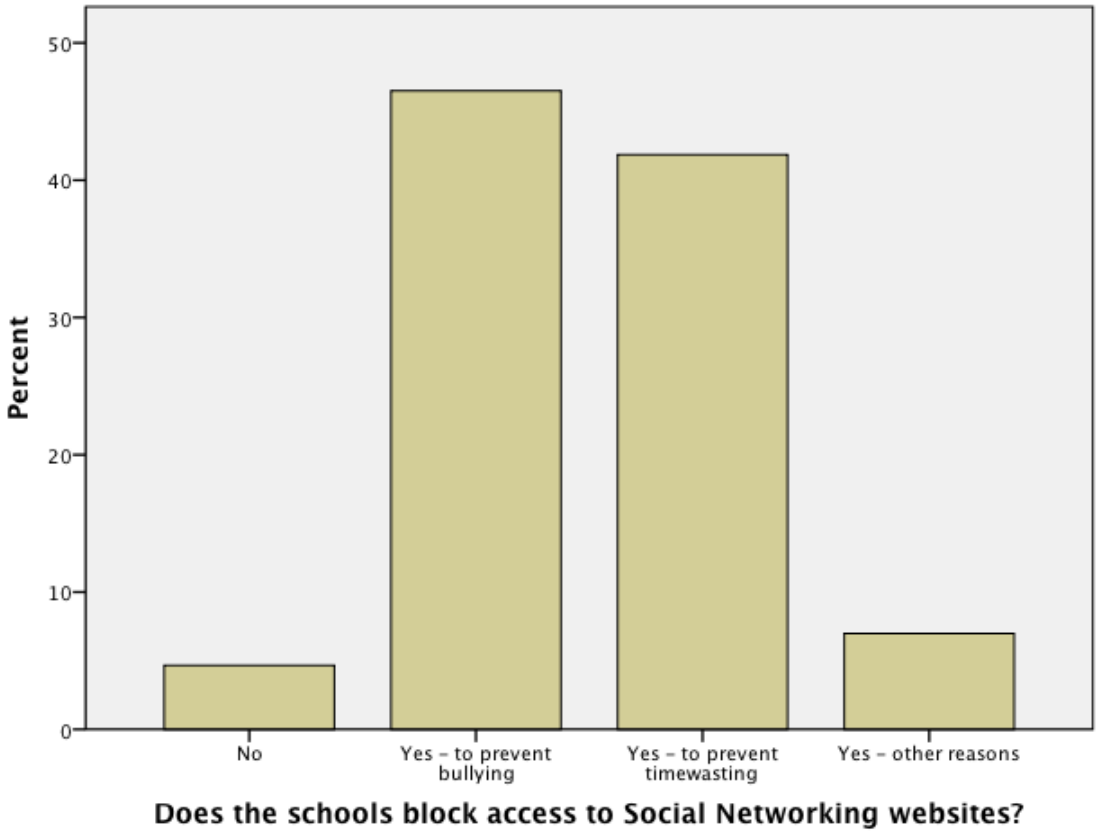

Figure 4-3 Social Networking

HEAnet manages the central filtering services and supplied the following figures for the entire post-primary schools network in Ireland, based on the actual filtering policy requested by the schools:

Table 4-2 – Filtering of social networking

Schools where social networking websites are permitted:	8.2%
Schools where social networking websites are blocked:	91.8%

4.6 Broadband service usage

One of the key questions in the survey asked whether schools regarded their broadband service as reliable enough to plan classes around. If schools and their teachers want to change the way classes are conducted, and integrate digital learning initiatives into their pedagogical approach they must be able to rely on the internet connection provided to the school. This has been claimed as one of the major advantages of the high-speed

broadband program by it's government sponsors, and a perceived lack of reliability of the consumer broadband services used previously was one of the motivating factors behind the government investment.

In that context the overwhelmingly positive response to this question from respondents (83% agreed it was reliable) suggests that the program is achieving it's objective

Examining the response in the context of how long each school has had its 100Mb connection, the positive response is high regardless of the length of time the broadband has been installed, whilst the one responding school that had not had the high-speed service installed unsurprisingly answered negatively about its current broadband service.

Table 4-3 – Reliability of broadband

	Reliable enough?		
Installed	Yes	No	Total
Since 2010	11	1	12
Since 2012	17	4	21
Since 2013	7	1	8
Not installed yet	0	1	1
Total	35	7	42

As to whether the 100Mb service was more reliable than that which it replace, the results match those of the previous question, which again is a positive result for the reasoning behind the introduction of high speed broadband. Those schools that agreed that the service was reliable, all also agreed that it was an improvement over the previous broadband service that they used (with the implication that they had moved from an unreliable to a reliable service).

Breaking this result down based on length of time installed, all the responses rated neutral or negative are from the schools installed in 2012 and 2013, suggesting that attitudes to the relative reliability of the service may improve the longer the service has to "bed-in" (this may also be as the school's own infrastructure received additional investment to maximise the utility of the high-speed broadband), though analysed as a binary Yes/No proposition for Pilot (2010) schools versus others, the p-value is .067 so not quite statistically significant:

Table 4-4 – Relative reliability of broadband

		More reliable?		
		Yes	No	Total
Pilot School	Yes	12	0	12
	No	23	7	30
Total		35	7	42

A further question about internet usage in individual subjects found that History and Geography classes feature high levels of usage in over a third of schools, and over 75% of respondents reported some level of usage in all the subject categories. Business subjects had the highest proportion of schools reporting little or no use of the internet in classes, but even here the figure was only 17%.

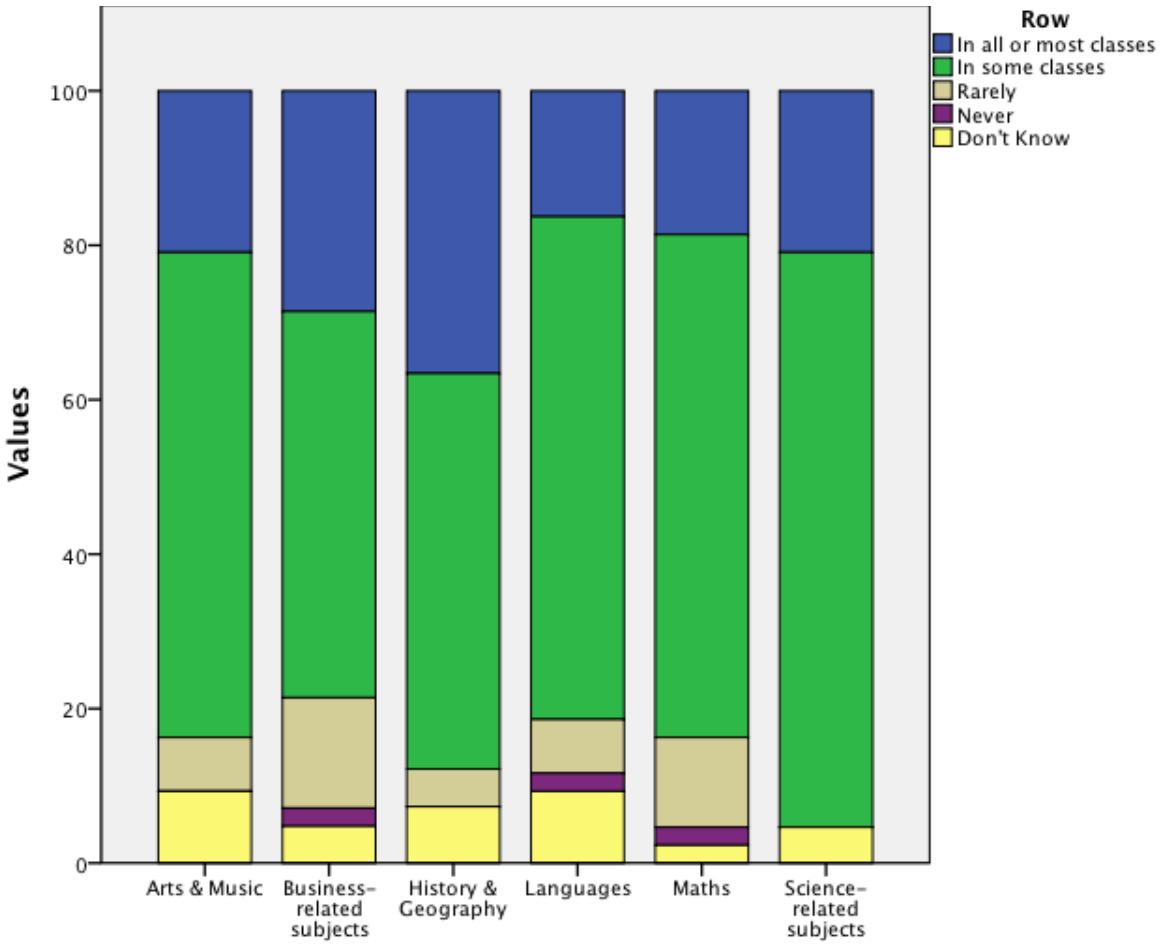

Figure 4-4 Internet usage by subject

4.7 Technology Use

In this section of the survey schools were asked about their usage of specific internet-enabled services:

- Video-conferencing services
- Cloud services for storage and remote applications
- VOIP (voice over internet protocol) – a low cost alternative to traditional telephony services
- Parental Communication services
- Local Server hosting

Video-conferencing has long been proposed as possible "killer" application for internet-enabled education and a number of the studies in the literature review examined it's use for distance education, guest lecturers etc. (Comber *et al.* 2004; Smyth 2005). More specifically from within the high-speed broadband project some of the publicity material has heavily featured some video-enabled activities such as the streamed higher-level maths classes between two Dublin schools included in the National Digital Strategy document. (DCENR 2013)

However the data shows that uptake of video-conferencing even among schools with a high-speed and reliable internet link is poor, with only 20% of respondents saying that it is in use in their school, and 80% of those only using video-calling service Skype, which would suggest a fairly casual use of the technology compared to the use of dedicated units.

The supplementary question on how video-conferencing was used in classes revealed a few different scenarios:

- Inter-school projects
- Class Project work
- Communicating with other European and African schools (in the case of the African school the call had to be ended as the African broadband link failed)

Two schools also stated that they use video-conferencing for remote classes with one respondent stating that it was used for providing teaching to an individual student in a subject that was otherwise unavailable at the school. A teacher in a different school allowed the student to attend classes virtually via Skype. This is the sort of small-scale inter-school collaboration that the availability of reliable broadband can facilitate and it could offer schools the opportunity to expand the range of subjects they provide through remote collaboration.

In contrast to the low usage of video-conferencing, uptake of cloud services was high at 70% of respondents. Moving internal schools infrastructure to cloud providers makes financial and operational sense for many schools as it removes some of the burdens of maintaining servers, operating systems, software licenses etc. It does place a greater importance on the reliability of the internet connection, so should be a more attractive option for schools moving to a high-speed network.

There was no statistically significant link between how long a school had been using the high-speed service and the likelihood of using cloud services (p=0.6) but "Cloud Services" is quite a broad term and a school could still use (for example) cloud backup services on a less reliable connection, even if they would be reluctant to rely on the cloud for all data storage.

Dropbox and Google Apps were the most used services of those specified suggesting that data-storage and backup is the more popular service but some schools are using Office365 as well as Educational social network Edmodo suggesting a gradual uptake of Cloud Applications as well.

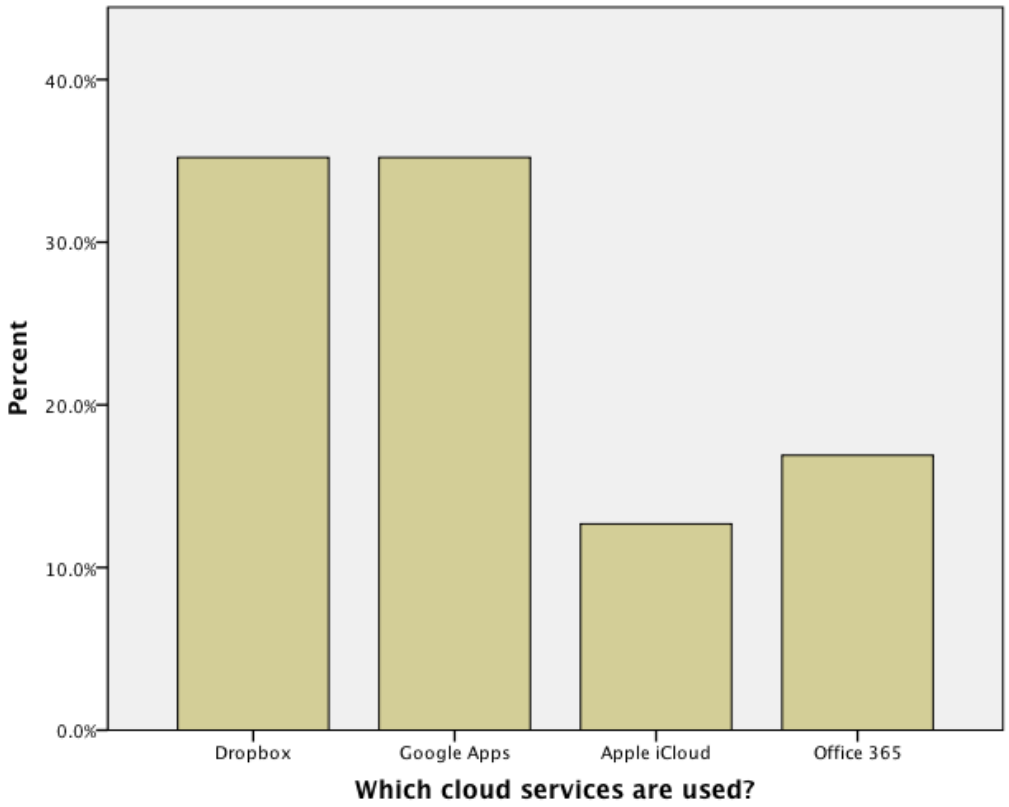

Figure 4-5 Cloud Services

The final three questions looked at how schools are utilising broadband to improve administrative and operational tasks outside of the classroom, and potentially saving money. VOIP as a technology has been a moderate success in the commercial and

domestic telecommunications sectors with service-providers such as Irish company Blueface offering call-plans that undercut traditional fixed line operators (Kennedy 2011).

However uptake of VOIP in the schools surveyed is very low with only 2 positive responses. It is likely that schools regard their landline service as critical and may be reluctant to change to a technology that they perceive (rightly or wrongly) as less reliable, even if it offers financial savings. It is also possible that landline call costs are not significant enough for most schools for them to give it much consideration.

Communicating with parents via the Internet is another service that offers an opportunity for schools to save time and money over traditional approaches (such as sending printed letters home in students' schoolbags).

The favoured method in most of the schools surveyed is webtext services such as "Text-a-parent", which is not surprising given the ubiquity of mobile phone use amongst the population in general – there can be few parents who do not carry a mobile with them most of the time.

Twitter, whilst often lauded in the press for its ability to provide one-to-many communication (a feature that would seem ideal for schools communicating with parents) is only used by 10% of the schools, and usage of Twitter amongst parents is probably not high enough for any schools to consider using it as a primary communication channel. The total number of active users on Twitter is still only 20% of those on Facebook (Facebook 2014; Twitter 2014), and usage of the latter by schools for parental communication is even lower in the survey than Twitter.

Schools were also asked if they were using the high-speed connection to host public-facing services on the local network. There is a slight paradox here, in that whilst the provision of high-speed broadband into schools could allow them to utilize cloud-services and move some previously local services off the the local network; the improved reliability and symmetric nature of the high-speed link also allows schools to host some services locally, which may not have been practical using a low-bandwidth asymmetric broadband link.

Mail and web servers, the latter for hosting the school's own website and blogs, are the most likely candidates for this local hosting and this approach does offer the potential for schools to save money over the costs of external commercial hosting. However moving these services "in-house" requires an amount of technical knowledge, and it remains to be seen whether this will continue to be an attractive option as cloud hosting becomes even more ubiquitous and cheaper. Google and Microsoft already offer free email domain hosting for educational institutions (Kennedy 2007), but some schools may prefer to keep

their email servers local for reasons of privacy and security. A little over half of the schools that answered this question are hosting some servers on their local networks.

A number of schools also stated that they were using the broadband link to monitor network-enabled CCTV cameras within the school. As schools often have problems with vandalism and theft this is a useful option for them and a number of companies now offer 24-hour security monitoring using IP cameras over the internet specifically marketed at schools (Netwatch 2013).

Access to Building Management Systems such as remote monitoring and control of lighting and heating is also mentioned – this is an area that is likely to become more popular if the much-hyped "internet of things" becomes a reality (IBM 2014).

4.8 Other Comments

At the end of the survey respondents were invited to comment on their experience of the high-speed broadband service in general, or on any aspect that the previous questions did not cover.

Of the 16 respondents who chose to comment, 7 had largely positive feedback on the impact the service has had in their schools, with the more enthusiastic comments including:

- *Much more stable and reliable. Can plan to develop around it.*
- *Provision of this broadband service has absolutely changed the way teachers teach and pupils learn in a positive way.*
- *The fact that we have 100mb broadband makes teaching using technology easy. We use Eportal for attendance in every class which couldn't be done perfectly without the high speed broadband. Every subject uses resources online which need to be done in real time which again couldn't be done without high speed broadband.*

With one school speculating:

- *… we will need in excess of 200mb in the next 5 years.*

6 Other comments focused on how the investment in broadband has been undermined by a lack of investment in other areas of infrastructure, in particular in providing Wi-Fi to all areas of the school so that users can take advantage of the enhanced broadband service:

- *Investment in wireless technology in all schools would enable the best usage of broadband in the form of portable devices for teachers and students.*

- *We don't have enough wireless points throughout the school - these need to be extended so that the wifi can be accessed anywhere a student moves in the school.*
- *Greater use would be made in my school if wi fi were more widely available but we can't afford to install it.*
- *We have fantastic Broadband, but have an Old Network, Hubs, Servers and PCs that are throttling it, which prevent the use of it to anything near its potential.*

Other comments suggested that teachers are not sufficiently trained to fully utilise the possibilities of digital education:

- *Teachers require more training.*
- *Training is most NB on the new technologies.*
- *The students currently use their tablets simply for ebooks.*

This final comment on use of tablets shows some frustration at how despite the introduction of new technologies the curriculum is merely "digitising old practises" (as discussed by Evers and Puttnam in the introduction chapter) rather than encouraging innovative change in the way subjects are delivered.

4.9 Summary of survey findings

One of the stated aims of the high-speed broadband program is to provide schools with a broadband service that is reliable enough to build lesson plans around:

In order to facilitate students in developing ICT skills access to fast reliable broadband is essential (Hogan 2013).

The data (and comments) from the survey show that schools do believe the service is reliable, and the longer they have the service the stronger this belief is, which should make the integration of the internet in classes more likely. All subject groups are already using the internet in classes to some degree, which suggests there is already a move away from the exclusively maths and science focused ICT activity of the past.

The trend towards providing students with individual devices is apparent. Earlier surveys on ICT activity in Irish schools found pupil:computer ratios lagging behind international levels (NCTE 2006). Combined with the finding on internet usage in class it shows schools are making progress toward the goal of integrating ICT into lessons on a routine basis, though what isn't captured in the data is the type of activity taking place, and whether it involves interacting with online material or merely digitises old practices.

However the comments from respondents indicate that they still feel restricted by shortcomings in other areas such as the internal ICT infrastructure of the school, and a lack of training and curriculum development to allow the maximal use of the internet within the classroom and a significant move towards the sort of digital learning the government envisions in its Digital Strategy.

At a more technical level the availability of broadband is allowing the schools to leverage the opportunities of cloud technologies though it is not clear if the sort of interactive, online applications and services enabled by high-speed broadband are being widely utilized yet; and in the area of real-time communication using voice and video progress appears to be slow.

Overall the message from the survey data is that high-speed broadband is just one of the elements required to modernize the school environment and pedagogical practices within the classroom, and that other elements such as investment in internal infrastructure, support services, teach training and curriculum updates are either not being provided centrally, are being provided in too slow and piecemeal a manner, or are being left to the initiative of individual schools and their teachers.

5 CONCLUSIONS AND FUTURE WORK

5.1 Preamble

The Irish government has committed millions of euros to the installation of high-speed broadband in post-primary schools. While the total cost of the program won't be known until it is completed at the end of 2014, an initial cost of €13m was projected at the time of the pilot scheme (Ryan 2010). It is important that this investment has a definite and lasting effect on the schools receiving it, both in how they deliver educational content and in how they go about their everyday institutional activities.

It is therefore vital that the impact of this program is assessed to ensure it that it is having the desired outcomes. This research has examined a number of different aspects of school operation, seeking the perspective of those closest to the implementation of ICT policy within the organisation – the "ICT coordinator", whether that is the principal, or a designated teacher or other relevant person.

The data returned from this research shows that in general schools are moving towards utilising ICT more pervasively at both a pedagogical and organisation level, but that this process is relatively slow. However the positive sentiment towards the reliability and suitability of the high-speed service for in-class use, and the high rate of actual use across all subjects bodes well for sort of digital education landscape envisioned by the government in pushing forward with investment in this project.

5.2 General findings

There is clear enthusiasm within the schools for the installation of high-speed broadband, but schools' own internal network infrastructure needs to be upgraded to take full advantage of the new service. 100Mb/s access to the internet is of little use if the Wi-Fi network in a school is outdated and cannot provide access to large numbers of simultaneous users at the required speeds. Some schools do not have any Wi-Fi network installed and it is questionable whether they will see any benefit from the high-speed connection until this is remedied.

Providing students with individual devices appears to be important for the introduction of digitally-enabled learning, but which devices are preferred and how they are financed is currently a matter for individual schools to decide, and there is both confusion at the best approach to take (tablets may be better for interacting with online material, but for work that involves writing, design-work, programming etc. laptops may be more practical); and there is frustration from some teachers that individual devices, where available, are not being used to their full potential.

Once students do have their individual devices “in-hand” there remains concerns of how much freedom-of-access they are given to internet resources, with many schools still favouring a relatively restricted approach amid concerns about time-wasting and online bullying.

Perhaps the most encouraging finding within the data is that teachers have a strong positive reaction towards the broadband service itself and regard it as both reliable enough to use in the classroom and plan activities around; and as a substantial improvement on the broadband service their respective schools used previously.

Also internet-based resources, where available and accessible, are being used across a wide range of subject groups. Although in the past ICT use has tended to be more prevalent in the “STEM” (Science, Technology, Engineering, Maths) subjects, Irish schools are now using the internet frequently in other language and humanities type subjects. Furthermore there is a belief amongst those responding to the research that the use of ICT is beneficial educationally, and more specifically in improving exam results. A caveat here is that those ICT coordinators responding may have a bias in favour of ICT in general; though possibly less so in the case of principals.

There is also a generally positive perception of the way in which the school curriculum has adapted to the availability of ICT and the internet, contrary to the misgivings expressed publicly by the teaching unions to some proposed curriculum reforms. However there is still some dissatisfaction with the levels of training and support offered to teachers to implement new technologies in the classroom.

The use of individual internet-enabled technologies within the classroom is variable. Video-conferencing and similar services for remote learning are used only sparingly and on a seemingly casual basis, whilst internet telephony is hardly being used at all. Cloud services for storage of data and provision of remote applications are being used by a number of schools and this might be expected to increase as schools realise some of the advantages of these services, and the major providers continue to target the educational market. However schools with concerns over security of data also have the option of leveraging the improved internet connection to host services locally (as some are already doing).

The broadband service is also providing some administrative advantages to schools, with internet CCTV and building management systems in use, and schools using online text-message services (and to a lesser extent social networking) to communicate with parents.

5.3 Limitations and Generalisability

The findings outlined here are as a result of quite a limited survey response, and there is (as previously discussed) some danger of response bias in the participants.

Whilst the data for this study has come specifically from Irish post-primary schools, and some of the results do relate to particular issues within that sector (such as funding and curriculum development), there is no reason that the findings cannot be considered applicable to the wider Irish educational community, or to similar international projects.

There is at least anecdotal evidence that Irish primary schools are finding their use of ICT restricted by poor access to broadband (Murray 2014) and the extension of a similar program of upgrades to those schools could be predicated on the success of the post-primary project. Evidence of widespread use of internet content and increased confidence in ICT use amongst teachers is a positive factor and should be applicable in a primary education context also.

From an international perspective, other countries such as the UK (Savvas 2014) and South Africa (Analysys Mason 2014) are considering their strategies for promoting digital education through broadband provision and may want to look to the experience of schools in Ireland.

5.4 Further Research

A number of alternative research approaches were considered and outlined in the Research Approach chapter, and in some cases have been used in research in other countries. These may still be useful approaches to take in further examining the effectiveness of the high-speed broadband program in Ireland.

The survey data from this study found that teachers subjectively do consider internet usage in class to be beneficial to students in state exams. A correlation of internet usage against exam results, in a similar manner to the work carried out by Belo *et al.* (2010) would require a longer term study, and would necessitate careful design and calibration to compensate for external factors. Whilst one school might show greater internet usage than another, this would have to be shown to be actual classroom educational usage for it to have any bearing on the effect on exam results (e.g. a school using cloud services for data storage would transmit a lot more data over it's internet connection than an equivalent school using local storage). Examining the actual applications in use and classifying them as educational or non-educational could refine this approach. There are also many other external factors that could affect exam results such as class sizes, teacher experience etc.

A longitudinal case study of one or more schools using the broadband service could also produce interesting results in the context of examining whether actual ICT usage in the classroom increases over time, and what other factors influence this. This would probably produce a more qualitative descriptive finding, as the major differentiator between different schools is likely to be the pedagogical approach of the individual teachers participating in the study.

Repeating the survey carried out for this paper over a period of several years with the same sample of schools would provide a more longitudinal view of how the schools develop their ICT environment alongside the long term availability of high-speed broadband. The Economic and Social Research Institute (ESRI) is currently carrying out such a long-term study on behalf of the government to ascertain the impact of their substantial investment, but the final results of this research may not be known for several years (ESRI 2013).

5.5 Final Conclusions

Returning to the original research question - "what is the impact of high-speed broadband in Irish schools" - there is no single answer, rather a few separate trends that have been observed:

- Whilst there is clear progress in some areas, the impact in other areas is minimal, and the research suggests that high-speed broadband is not a single solution to the promotion of a new form of digital education.
- Where schools are seeing an impact, it is in enabling them to plan classes that incorporate ICT and the internet, whilst have a strong degree of confidence that the technology will work. However "technology" in this case is not limited to just the broadband connection, and schools are still experiencing issues with local infrastructure and support.
- Also the technology is just one factor and there are still concerns over training and (to a lesser degree) curriculum development.

Nevertheless, it could be argued that reliable high-capacity broadband is a pre-requisite to the introduction of other technologies (such as tablets) and to the introduction of new pedagogical approaches, so it is inevitable that these factors will lag behind to some degree. The concern would be if planning is not in place for these elements to be introduced promptly, as otherwise the investment in broadband might not produce the envisioned positive outcomes.

Provision needs to be made for additional investment in both technology and people to complement the investment in broadband; if this can be achieved then the prospects of

this broadband project delivering meaningful change within the Irish education system are good.

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Appendix 2 Survey Questions and Response Tables

How long has the school had its 100Mb connection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Since 2010	13	28.3	29.5	29.5
	Since 2012	22	47.8	50.0	79.5
	Since 2013	8	17.4	18.2	97.7
	Not installed yet	1	2.2	2.3	100.0
	Total	44	95.7	100.0	
Missing	0	2	4.3		
Total		46	100.0		

Devices in use in the school:

Desktops

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	44	95.7	100.0	100.0
Missing	Not ticked	2	4.3		
Total		46	100.0		

Laptops

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	42	91.3	100.0	100.0
Missing	Not ticked	4	8.7		
Total		46	100.0		

Tablets

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	24	52.2	100.0	100.0
Missing	Not ticked	22	47.8		
Total		46	100.0		

eReaders

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3	6.5	100.0	100.0
Missing	Not ticked	43	93.5		
Total		46	100.0		

Other Devices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3	6.5	100.0	100.0
Missing	Not ticked	43	93.5		
Total		46	100.0		

What is the most common scenario for computer usage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Computer Lab	34	73.9	73.9	73.9
	Shared PC in classroom	1	2.2	2.2	76.1
	Individual devices in classroom	11	23.9	23.9	100.0
	Total	46	100.0	100.0	

Does the school have a wifi network

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	33	71.7	75.0	75.0
	No	11	23.9	25.0	100.0
	Total	44	95.7	100.0	
Missing	0	2	4.3		
Total		46	100.0		

Is there a written internet usage policy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	45	97.8	100.0	100.0
Missing	0	1	2.2		
Total		46	100.0		

Is there an assigned IT coordinator

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	35	76.1	77.8	77.8
	No	10	21.7	22.2	100.0
	Total	45	97.8	100.0	
Missing	0	1	2.2		
Total		46	100.0		

Who holds the IT coordinator role (more than one answer allowed)?

Principal

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	15.2	100.0	100.0
Missing	0	39	84.8		
Total		46	100.0		

Teacher

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	34	73.9	100.0	100.0
Missing	0	12	26.1		
Total		46	100.0		

IT Committee

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	10	21.7	100.0	100.0
Missing	0	36	78.3		
Total		46	100.0		

External Person

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	13.0	100.0	100.0
Missing	0	40	87.0		
Total		46	100.0		

Other

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	2.2	100.0	100.0
Missing	0	45	97.8		
Total		46	100.0		

Teachers are receiving sufficient training/guidance to make full use of the broadband service

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	3	6.5	9.1	9.1
	Disagree	16	34.8	48.5	57.6
	Neutral	5	10.9	15.2	72.7
	Agree	8	17.4	24.2	97.0
	Strongly Agree	1	2.2	3.0	100.0
	Total	33	71.7	100.0	
Missing	0	13	28.3		
Total		46	100.0		

The use of the internet in classes has a positive effect on exam results

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	13	28.3	39.4	39.4
	Agree	15	32.6	45.5	84.8
	Strongly Agree	5	10.9	15.2	100.0
	Total	33	71.7	100.0	
Missing	0	13	28.3		
Total		46	100.0		

The school curriculum has adapted to the availability of new technologies in the classroom

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	2	4.3	6.1	6.1
	Disagree	8	17.4	24.2	30.3
	Neutral	4	8.7	12.1	42.4
	Agree	14	30.4	42.4	84.8
	Strongly Agree	5	10.9	15.2	100.0
	Total	33	71.7	100.0	
Missing	0	13	28.3		
Total		46	100.0		

Are students permitted to use their own devices on the network?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	17.4	19.0	19.0
	No	34	73.9	81.0	100.0
	Total	42	91.3	100.0	
Missing	0	4	8.7		
Total		46	100.0		

Are measures in place to restrict students' access to the internet during class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	34	73.9	81.0	81.0
	No	8	17.4	19.0	100.0
	Total	42	91.3	100.0	
Missing	0	4	8.7		
Total		46	100.0		

Are students permitted to use the network outside of formal classes (e.g. after school or during breaks)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	41.3	44.2	44.2
	No	24	52.2	55.8	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

Does the schools block access to Social Networking websites?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	2	4.3	4.7	4.7
	Yes - to prevent bullying	20	43.5	46.5	51.2
	Yes - to prevent timewasting	18	39.1	41.9	93.0
	Yes - other reasons	3	6.5	7.0	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

In your opinion is the school's current internet service reliable enough for teachers to plan classes around?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	78.3	83.7	83.7
	No	7	15.2	16.3	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

Is the 100Mb internet service more reliable than the school's previous internet service?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	78.3	83.7	83.7
	No	1	2.2	2.3	86.0
	About the same	5	10.9	11.6	97.7
	N/A (not installed)	1	2.2	2.3	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

How frequently is the internet used during classes in the following subject categories?

Maths

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	8	17.4	18.6	18.6
	In some classes	28	60.9	65.1	83.7
	Rarely	5	10.9	11.6	95.3
	Never	1	2.2	2.3	97.7
	Don't Know	1	2.2	2.3	100.0
	Total	43	93.5	100.0	
Missing	9	3	6.5		
Total		46	100.0		

Languages

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	7	15.2	16.3	16.3
	In some classes	28	60.9	65.1	81.4
	Rarely	3	6.5	7.0	88.4
	Never	1	2.2	2.3	90.7
	Don't Know	4	8.7	9.3	100.0
	Total	43	93.5	100.0	
Missing	9	3	6.5		
Total		46	100.0		

Science-related subjects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	9	19.6	20.9	20.9
	In some classes	32	69.6	74.4	95.3
	Don't Know	2	4.3	4.7	100.0
	Total	43	93.5	100.0	
Missing	9	3	6.5		
Total		46	100.0		

Arts & Music

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	9	19.6	20.9	20.9
	In some classes	27	58.7	62.8	83.7
	Rarely	3	6.5	7.0	90.7
	Don't Know	4	8.7	9.3	100.0
	Total	43	93.5	100.0	
Missing	9	3	6.5		
Total		46	100.0		

Business-related subjects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	12	26.1	28.6	28.6
	In some classes	21	45.7	50.0	78.6
	Rarely	6	13.0	14.3	92.9
	Never	1	2.2	2.4	95.2
	Don't Know	2	4.3	4.8	100.0
	Total	42	91.3	100.0	
Missing	9	4	8.7		
Total		46	100.0		

History & Geography

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In all or most classes	15	32.6	36.6	36.6
	In some classes	21	45.7	51.2	87.8
	Rarely	2	4.3	4.9	92.7
	Don't Know	3	6.5	7.3	100.0
	Total	41	89.1	100.0	
Missing	9	5	10.9		
Total		46	100.0		

Does the school use Video Conferencing services?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	9	19.6	20.9	20.9
	No	34	73.9	79.1	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

What video conferencing services does the school use?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dedicated VC units	3	6.5	23.1	23.1
	Skype	10	21.7	76.9	100.0
	Total	13	28.3	100.0	
Missing	0	33	71.7		
Total		46	100.0		

Does the school use cloud services?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	30	65.2	69.8	69.8
	No	13	28.3	30.2	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

Please indicate which cloud services the school uses:

Office 365

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	26.1	26.1	26.1
	2	34	73.9	73.9	100.0
	Total	46	100.0	100.0	

Google Apps

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	25	54.3	100.0	100.0
Missing	0	21	45.7		
Total		46	100.0		

Dropbox

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	25	54.3	100.0	100.0
Missing	0	21	45.7		
Total		46	100.0		

Apple iCloud

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	9	19.6	100.0	100.0
Missing	0	37	80.4		
Total		46	100.0		

Does the school use a VOIP service (such as Blueface) for its telephones?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	2	4.3	4.7	4.7
	No	41	89.1	95.3	100.0
	Total	43	93.5	100.0	
Missing	0	3	6.5		
Total		46	100.0		

Does the School use any online services to communicate with parents (check all that apply)?

Twitter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	17.4	100.0	100.0
Missing	0	38	82.6		
Total		46	100.0		

Facebook

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	5	10.9	100.0	100.0
Missing	0	41	89.1		
Total		46	100.0		

Email

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	15	32.6	100.0	100.0
Missing	0	31	67.4		
Total		46	100.0		

Webtext services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	41	89.1	100.0	100.0
Missing	0	5	10.9		
Total		46	100.0		

Does the school host its own servers (e.g. web and mail servers) on the school network?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	23	50.0	56.1	56.1
	No	18	39.1	43.9	100.0
	Total	41	89.1	100.0	
Missing	0	5	10.9		
Total		46	100.0		