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Devitt, Niamh and Lyons, Sean and McCoy, Selina

Economic and Social Research Institute, Trinity College Dublin

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Niamh Devitt,[a] Seán Lyons[a,b] and Selina McCoy[a, b,*]

[a]*Economic and Social Research Institute, Dublin*

[b]*Trinity College Dublin*

[*] Corresponding author. Address for correspondence: ESRI, Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland. Email: selina.mccoy@esri.ie, Tel: +353 1 863 2059

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Abstract

As part of Ireland's National Digital Strategy high-speed broadband is being rolled-out to all second-level schools to support greater use of ICT in education. This programme signals a move from slow and unreliable broadband connection for many schools to a guaranteed high-speed connection with technical support. Theoretically, this should allow for behaviours and pedagogies to adapt incorporating ICT into education. Research shows that integrating ICT into teaching and learning is a gradual process for most teachers and is influenced by a complex mix of socio-technical factors. Our dataset consists of survey data from teachers and principals from a sample of second-level schools. The survey collected factual and attitudinal variables including attitudes towards ICT integration, current availability of infrastructure and barriers to ICT use, before schools received high-speed broadband connectivity. We examine the factors influencing teachers' attitudes to ICT and their perceived barriers in adopting new technologies in their day-to-day teaching. Analysis of this baseline period is essential in an iterative digital strategy, informing future strategies, targeting policy most effectively and achieving policy objectives. While attitudes towards the potential of high-speed broadband and use of ICT are consistently positive across sub-groups of schools and teachers, perceived barriers to ICT usage differ.

Key words: High-Speed Broadband, ICT barriers, second-level education, student learning, ICT integration

1. Introduction

A report by the European Commission (2014) on the growth potential of ICT (Information and Communication Technology) in Europe identifies the lack of ICT skills, underinvestment in ICT infrastructure and even cultural constraints as some of the hindrances to the innovation and growth effects of technology. The role of ICT in the economy is undeniably growing in importance with mobile broadband internet, big data, cloud computing and e-commerce becoming prevalent in economic and social activities. As such, the Digital Agenda for Europe 2020 sets out a number of goals for the digital economy emphasizing ICT as central to European competitiveness and economic growth. Two elements of this agenda are fast or ultra-fast broadband and enhanced digital literacy, skills and inclusion. High-speed broadband provision is intended to encourage the use of ICT in a multitude of economic and social areas thus providing the opportunity to create jobs, improve productivity, service delivery and quality of life. The education system will play an influential role in embedding enhanced digital literacy and skills into society.

As part of Ireland's National Digital Strategy, the Irish government is investing substantially in a national roll-out of high-speed broadband to all second-level schools in the country. This investment signals a move from slow and often unreliable broadband connection that inhibits use of ICT within education to a high-speed reliable broadband connection with technical support. With this higher quality broadband connection comes a new set of challenges; how can ICT support, enhance or transform teaching and learning in schools? This significant investment has a lot of potential; allowing simultaneous access by teachers and students, high-speed link to 'the cloud', streaming video, remote teaching etc.

Previous literature has suggested that rather than focusing on improvement in traditional cognitive performance, ICT use within the education system could help develop students' independent learning skills, critical thinking, problem solving, transversal skills as well as purely technological skills. These skills are vital for excelling in post-school education and are increasingly indispensable for living and working in the 21st century. The phased roll-out of high-speed broadband into schools provides us with an opportunity to conduct a rigorous impact assessment of this programme. An initial educational impact assessment for this programme was carried out on a pilot group of 78 schools and reported in DCENR (2012b). It employed a mixed methods approach including a survey of schools after implementation of

the service. The results were encouraging, reporting positive attitudes towards ICT among teachers, active planning and access to training for ICT use within schools, increased collaboration within and between schools, wider use of online resources, and gains in flexibility, innovation and student engagement. However, the pilot study did not collect data prior to installation of high speed broadband, which would have been preferable for allowing a comparison of educational outcomes before and after the programme's implementation.

This paper examines survey data collected from the period before installation of high-speed broadband in a further 436 schools. The dataset will be supplemented with a post-installation survey some time after high-speed broadband has been installed in all schools as part of the broader study. The aim of this broader study will be to investigate the impact of a significant high-speed broadband investment on teaching and learning outcomes. Analysis of the baseline data is an essential step in this broader study in order to observe changes in behaviour that can be isolated and attributed to the government investment programme. The impact of this study of high-speed broadband will also play an important role in further policy planning and in supporting the broadband infrastructure with necessary investments in order to maximize the full potential of ICT within education. This paper specifically looks at the readiness of schools and teachers to integrate ICT into their pedagogical practices, their current use of ICT and their perceived barriers in this regard. This paper describes some previous literature examining the impact of ICT within education in section 2. Section 3 describes our methodology and data used, section 4 presents the results of our analysis and section 5 discusses these results and concludes.

2. Literature Review

The role of ICTs in education has been discussed at length and remains an area of great interest as governments continue to invest resources and education policy continues to adapt to incorporate ICTs. We examine some literature that highlights the central role ICT policy in education, studies on the impact of ICT and specifically broadband on student achievement, different methodologies used to estimate this impact and finally we look at obstacles to ICT integration.

ICT policy in Education

The European Commission has adopted a range of policies with respect to ICT use in education, most recently in its Digital Agenda 2010. Through its "TeLearn" project the European Commission is researching ways in which ICT can be used to enhance teaching and learning (European Commission, 2012)**.** In 2004, Ireland launched its Broadband for Schools Programme as a means to "significantly enhance the potential of ICT in teaching and learning" (DCMNR, 2004). The role of ICT in education was further emphasized by the Next Generation Broadband Taskforce which recommended that government continue to invest in broadband for schools and that "digital skills be a fundamental part of the school curriculum"(DCENR, 2012a). Progress in Europe in integrating ICT, however, has been uneven with differences apparent within and between countries, as well as between schools within countries (Balanskat *et al.*, 2006). 'What works' in integrating ICT is certainly difficult to measure. Papanastasiou and Angeli (2008) found that teachers' actual knowledge and use of various computer software for professional and personal purposes, teacher confidence and attitudes toward technology, the technology infrastructure and support in the schools, as well as teachers' beliefs about the use of technology as an agent for change all play a role in the successful integration of ICT in schools. It's clear from this study that the adoption of ICT is not merely a technical implementation; it is also about teacher beliefs, pedagogical practices and the potential to exploit ICT efficiently (Balanskat *et al*., 2006). ICT policy in education should reflect this and strive to provide the relevant supports.

Impact of ICT on student achievement

Opinion based studies such as the eLearning Nordic study (2006) look at the impact of ICT through self-reported perceptions of teachers and students. This is similar to the data used in this analysis where we use survey data on the perceptions of teachers and principals on ICT usage. The Nordic study finds positive effects with teachers convinced that students' subject-related performance and basic skills as well as educational achievements improve through ICT integration. Perception based results must be treated with caution, however, as they could be interpreting perceived impact as opposed to actual impact. Nevertheless, positive attitudes of teachers and students are a key component for successful ICT integration (Papanastasiou and Angeli, 2008) and therefore self-reported positive attitudes towards the use of ICT in teaching and learning is one of many important factors for successful ICT integration. However, even with teachers' positive attitudes towards the role of ICT in

learning outcomes, changes to their pedagogical approaches are "slow and measured" (Kerr 1991).

Results from quantitative studies show a positive impact of ICT use on student achievement. Meta-analyses such as by Kulik (2004), note that research has identified positive effects of specific ICT uses on pupil's educational attainment. At an international level, an OECD report found that there is a positive association between the length of time of ICT use and students' performance in PISA mathematics tests (OECD, 2004). A report from the Growing Up in Ireland Longitudinal Study of children shows that "internet access in the classroom plays an important role in children engaging in social networking outside school" and even taking account of a wide range of background factors "children who engage in cultural activities and social networking perform better in reading and mathematics than other groups" (McCoy *et al*., 2012). Thus, the authors' state, internet access in the classroom can lead to an "enhancement of a range of cognitive skills rather than literacy alone" and has implications for the wider usage of ICT among children. Conventionally, these studies have tried to establish a causal link between use of ICT and student outcomes using students' academic performance, with some associated difficulties. First, results are often based on simple correlation between ICT and student performance (Kirkpatrick and Cuban, 1998). Angrist and Lavy (2002) address the possible endogeneity in the use of ICT and students' test scores through a randomised control trial and found no evidence that educational use of computers raised pupil test scores. Leuven *et al.* (2004) used a quasi-experimental method and conclude similarly that the extra funds for computers and software did not have a positive impact on pupils' achievement.

Second, the measurement of ICT usage may be flawed. Many studies analyse the impact of investment in or simply the *access* to ICTs and not actual *usage* of ICTs which could lead to bias on estimates of the effectiveness of ICT on educational attainment. For example, Goolsbee and Guryan (2006) study internet subsidies to public schools and found that subsidies for ICT investment were diverted to the most disadvantaged schools. However, the authors themselves express doubt about whether resources were actually used not least because teachers were novice or completely inexperienced with computers.

Finally, the impact of ICT and broadband may not be measured effectively through traditional measures of student achievement. Ruthven *et al*. (2004) in the UK argue that while

the internet was widely recognised as having educational potential, there was less clarity about how this might be realised in classroom teaching and learning. Many studies note that the ICT may impact unobserved elements of student performance and students' motivation, independent learning and teamwork (Goolsbee & Guryan 2006, Belo, Ferreira & Telang, 2011, OECD, 2001). A report by the Irish Department of Education and Skills (DES) based on case-studies of over 50 schools, inspections of 180 schools and survey evidence from almost 1400 teachers, over 900 principals and students, found that "ICT impacts predominantly on the development of students' research and investigation skills, as well as their writing and presentation skills" (DES, 2008). These ICT driven skills are not fully exploited in traditional pedagogies or measured explicitly in traditional measures of student achievement. Neglecting to incorporate these broader skills in student achievement measures may underestimate the impact of ICTs on learning outcomes.

Looking specifically at the impact of broadband on student achievement, Underwood *et al.* (2005) finds in UK schools that broadband access in classrooms results in significant improvements in pupils' performance in national tests taken at age 16. However, Belo, Ferreira and Telang (2011) look at the effects of actual usage of broadband in schools in Portugal, measured by the amount of information exchanged with the Internet over ADSL connections, and find that broadband usage over the period 2005-2009 had an adverse effect on school performance. There are a number of possible reasons for this adverse effect of ICT on student achievement; concerns about the endogeneity of the relationship between education inputs and student achievement and unobserved factors biasing the results. The authors' have no information on what the broadband is used for and so could have been used for unproductive purposes. Similarly to ICT in general, broadband may still be beneficial for students in ways that test scores do not capture. These benefits are hard to measure but add to the potential of ICT in the education system.

Obstacles to ICT integration

The presence of ICT resources and infrastructure in schools are necessary but not sufficient for successful ICT integration in education. There are a number of supporting and hindering factors, ICT inputs just one factor in a complex mix that influences ICT integration. Machin *et al.* (2006) found the joint effect of large increases in ICT funding and a fertile background for making efficient use of ICT, appear to underpin positive effects of ICT expenditure on educational performance. Underwood *et al.* (2005) states that embedded, reliable and high-

capacity broadband in the classroom increases the quality and quantity of educational activities. Embedding ICT in education is influenced by other educational inputs and entails innovation and change at all levels of the school environment (OECD, 2001). A report by Gleeson *et al*. (2001), for example, based on six case study schools in Ireland concluded that the role of technology had been one of additional resource rather than a catalyst for ICT integration and many were still severely hampered by technical difficulties. A DES report (2008) highlights the ongoing maintenance and replacement of hardware within schools and the provision of increased opportunities for teachers to engage in relevant teacher training as central to the development of ICT in schools.

Schools that were more successful in implementing ICT were characterised by positive school leadership, the presence of an effective IT specialist and the availability of professional support and guidance. This highlights the complex relationships between first-order influences such as access to reliable technology and second-order influences such as teacher attitudes and skills in the integration of ICT (Underwood *et al.*, 2005). Hennessy *et al*. (2005) in the UK examines how secondary teachers of the core subjects of English, Mathematics and Science have begun to incorporate ICT into mainstream classroom practice. They state lack of adequate access to technology, experience and confidence in using ICT as well as lack of professional control linked to the pressure to conform to centralised curriculum and assessment systems as obstacles to ICT integration. Similarly, Pelgrum (2001) and Bingimlas (2009) suggest the most important factor in the implementation of ICT is whether a teacher can arrange appropriate teaching opportunities for using ICT in a classroom or laboratory. Hence current school and classroom organisation and structures and pressure relating to state exams may be hindering greater use of ICT in teaching practices.

Balanskat *et al.*'s (2006) case studies highlight infrastructure issues – the quality of connectivity is a barrier in many schools, to the point of deliberately orienting students away from the web because of difficulties with the speed and reliability of the connection. Bingimlas' (2009) meta-analysis finds that while teachers had a generally positive attitude to implementing ICT in their teaching, they faced barriers such as lack of confidence, lack of relevant skills and inadequate access to resources. In addition school-level barriers arose such as limited access to ICT, poor quality and inadequate maintenance of hardware as well as unsuitable educational software. Moreover, the absence of an ICT dimension in schools' overall strategies and their limited experience with project-oriented activities supported by

ICT, are decisive in determining levels of ICT use by teachers (Eadie 2001). These studies combined point to the importance of teacher training as well as infrastructural support and school leadership in the integration of ICT.

3. Methodology and data

In this paper we use survey data collected from 436 second-level schools around the country before installation of high-speed broadband. This survey explores the attitudes of teachers and principals towards the use of ICT and the barriers they perceive in the use of ICT in their teaching and learning objectives before receiving reliable high-speed broadband. These data also provide us with information on the baseline usage of ICT in these schools before they received the high-speed broadband. In the future this baseline usage information can be combined with data from a post-installation survey to allow us to isolate the impact of broadband investment.

Our sample of second-level schools was surveyed in 2 groups: group 1 consists of second-level schools in Dublin, Meath and Kildare and group 2 schools in Waterford, Wexford, Cork, Kerry, Kilkenny and Limerick. The two groups were selected by the high speed broadband implementation team to facilitate a cost-effective phased roll-out of the programme. Group 1 schools received broadband service in the second half of 2013, and Group 2 schools received service in the second half of 2014. Our survey was administered to the schools prior to installation of broadband in both cases.

Although the schools were not selected at random, descriptive statistics show us that we have good variation in types of schools. Surveys were distributed to teachers and principals in our sample of schools. Principals were asked to nominate a random group of teachers of Maths, English and Science subjects at junior and senior cycle from each school and were asked to complete the surveys themselves also. These subjects were chosen to ensure consistency across schools and for comparison with international studies. In requesting teachers from specific subjects also we hope to minimise any selection bias in choosing teachers with the most ICT experience within the school. Response rate to the surveys can be seen in Table 1: 56% for both teachers and principals in group 1 and 56% for teachers, 69% for principals in group 2.

Table 1: Response rate for the pre-installation survey

	Target Sample	Achieved Sample	Response Rate
Group 1			
Principals	198	110	56%
Teachers	793	442	56%
Group 2			
Principals	236	162	69%
Teachers	780	438	56%

The surveys collected factual and attitudinal information: background and demographic information on both teachers and principals, current ICT infrastructure in the school, teachers perceived and actual use of ICT, the presence of an e-learning plan in the school, pedagogical approaches as well as self-reported and perceived challenges and obstacles in the integration of ICT into teachers' pedagogical practices.

As well as descriptive statistics and measures of correlation, factor analysis was carried out on the survey data. Due to the exploratory nature of the survey questions many of the answers are highly correlated and are likely representing underlying latent variables that we want to measure. Factor analysis enables us to describe these correlated observed variables as latent variables and so allows us to present the survey data in a convenient way for analysis. Table 2 presents the factor variables generated from the survey data and the questions that produce these factor variables. We use Cronbach's alpha (Cronbach, 1951) to test the internal consistency of our factor variables to gauge their reliability where a value of 0.7 is the cut-off for an acceptable factor variable.

Table 2: Factor Variables

Factor variable	**Reliability**	**Components**
Support_teaching **(dependent variable)**	$\alpha = 0.84$	Use curriculum-relevant online resources for lesson preparation Use applications such as word processing to prepare resources for class Create multimedia resources, incorporating sound, video, images or other digital media for class Use curriculum-relevant online resources to support their teaching
Support_learning **(dependent variable)**	$\alpha = 0.86$	I use ICT to: Support students to reflect on their own learning Support a range of student learning styles

		Provide differentiated learning or own-pace learning to support the development of numeracy Support the learning of students with special educational needs
Sufficient_resources	α = 0.84	Sufficient number of computers/laptops Sufficient number of internet-connected computers Sufficient number of interactive whiteboards
Sufficient_skills	α = 0.89	Adequate skills of teachers Sufficient training about how to use internet effectively in teaching and learning Lack of confidence among teachers using the internet (reversed)
Equipment_availability	α = 0.75	There is adequate provision of computing facilities in school There is adequate provision of audio-visual equipment in school
Internet_availability	α = 0.80	There is adequate provision of internet access for teachers in school There is adequate provision of internet access for students in school
Tech_support	α = 0.82	Adequate provision of technical support in school Maintenance of ICT equipment in this school is satisfactory
ICT_confidence (teacher variable)	α = 0.85	I feel confident to sue the internet in lessons to meet teaching goal I feel confident that computers/internet will help students understand concepts better I feel confident that I can use relevant software in my teaching I feel confident I can teach students to select appropriate software to use in their projects.
Adeq. ICT_resources (teacher variable)	α = 0.91	There is adequate provision of computing facilities in the school There is adequate provision of audio-visual equipment in the school There is adequate provision of internet access for teachers in the school There is adequate provision of internet access for students in school There is adequate provision of help with technical support in the school The school has up-to-date computing and audio-visual equipment The school has very good ICT facilities The maintenance of ICT equipment in this school is satisfactory
ICT_knowledge (teacher variable)	α = 0.93	How would you rate your knowledge about how to use computers in teaching your main subject? How would you rate your knowledge about how to use internet in teaching your main subject?

We segment the analysis into two main themes: attitudes towards ICT and the internet and perceived barriers to ICT usage. Teachers' and principals' attitudes towards ICT include the perceived value of ICT, the impact they feel ICT would have on diverse students and the impact it would have on their teaching. Perceived barriers to ICT usage cover four main areas; internet access and broadband speed, resources/equipment availability, teachers' skills and confidence and technical support and maintenance. We focus on two outcome factor variables, described in Table 1, that capture teachers' actual use of ICT in the classroom; *support_teaching* captures teachers' use of curriculum relevant online resources for lesson preparation and supporting their teaching as well as the use of applications such as word-processing to prepare for class. *Support_learning* captures teachers' use of ICT to support students to reflect on their own learning, supporting a range of student learning styles and supporting the learning of students with special educational needs. These variables are of

interest as they provide us with the baseline actual usage of ICT within the classroom and variables that should improve with the implementation of high-speed broadband.

We would expect that as teachers perceive more adequate internet access, equipment availability and technical support and maintenance this would encourage the use of ICT in teachers' own teaching practices and learning objectives. Similarly, as teachers' report greater confidence and feel they have the necessary skills and knowledge to use ICT this would encourage use of ICT in supporting teaching and learning. We would also expect to find that use of ICT in supporting teaching would encourage use of ICT in supporting learning and vice versa.

Training variables are also included, recording if teachers have taken introductory, intermediate or advanced internet training courses, courses on the pedagogical use of the internet, equipment specific training (with interactive whiteboards etc.) or ICT training from a member of staff. These dummy variables equal 1 if they have taken the relevant courses within the last two years and zero otherwise. We would expect a positive association with relatively recent training and the use of ICT in teaching and learning. An e-learning plan dummy is included as an explanatory variable which equals 1 if an e-learning plan is present in the school. The presence of an e-learning plan is expected to increase the use of ICT in teaching and learning as teachers are given direction and guidance in the use of ICT in their teaching and learning objectives.

The survey data were supplemented with administrative data on the second-level schools: school size and type; girls' secondary, boys' secondary, coeducational secondary, vocational or community/comprehensive schools and small, medium, big or very big schools; where small schools are schools with less than 200 students, medium schools have between 200 and 400 students, big schools have between 400 and 600 students and very big schools have greater than 600 students, enter the model as dummy variables. Vocational schools and very big schools are the reference categories for these groups. The association of schools of different size and their use of ICT relative to very big schools could be positive or negative. For a given connection speed, being in a large school may mean the available bandwidth is shared by more teachers and students at the same time, making it congested and slow. However, larger schools may also enjoy economies of scale in terms of resources and staff support in using ICT.

We also have additional information on schools' connection speeds before implementation of the 100Mbps high-speed broadband. A dummy variable of connection speed is included, equaling 1 if current connection speed is 10Mbps or higher and zero otherwise. We would expect a positive association between connection speed and use of ICT in teaching and learning; however, other quality factors may weaken this relationship (e.g. if broadband in schools is commonly characterised by unreliable connections). Unfortunately we do not have data on quality of service before installation of high speed broadband. The association between connection speed and ICT use is also likely to be affected by access to equipment and sufficient skills.

In order to capture the importance of school social mix and composition we include a measure of DEIS status (Delivering Equality of Opportunity in Schools), equalling 1 if a school has DEIS status and zero otherwise. There are 192 second-level schools participating in the DEIS school support programme focused on schools with a socio-economically disadvantaged intake. These schools benefit from a €3.4m ICT Grant Scheme for DEIS schools from the Education Disadvantage Fund (DES report, 2008). As a result of this targeted extra funding for ICT we would expect that ICT use supporting teaching and learning would be increased. To capture school composition we also include a dummy variable for special needs which equals 1 if there is greater than 25% of the students in the school with special educational needs and zero otherwise. A "group 2" dummy variable is included in addition to capture any difference between the two groups of schools, this equals 1 if the school is from the group 2 schools and 0 if the school is from group 1.

It is reasonable to think that a teacher's use of ICT may depend on the level of students' or teachers' familiarity with ICT outside of school. In order to incorporate this in to our model we use a socioeconomic background variable from the CSO's SAPS (Small Area Population Statistics) data; proportion of households with access to broadband internet was used in order to proxy the baseline level of ICT skills or usage that would be present in the school. We would expect as the number of households with broadband internet connection increases in the area that use of ICT in supporting teaching and learning would also increase.

Because we have only cross-sectional data, we cannot infer any causation as causality may work in both directions. However, we can test whether associations between variables operate

in the expected directions. Once the post-installation survey is completed and we have longitudinal data we hope to estimate causal relationships with ICT usage in teaching and learning.

Our two dependent variables are coded as dummy variables; which equal 1 if a teacher states they use ICT to support teaching or learning frequently or always and zero otherwise. We estimate logit regressions and then linear probability models on inclusion of interaction terms with the following functional form;

$$\boldsymbol{y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2s} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X * X + \varepsilon}$$

where $\boldsymbol{y_t = [0, 1]}$ and modelled at teacher-level, t. The dependent variables consist of vectors of teacher and principal characteristics; age, gender, experience and training. There is also a vector of school-level, s, characteristics; DEIS status dummy, group 2 dummy, school size dummies, school type dummies, e-learning plan dummy etc. Survey variables are included as categorical variables formed from the factor analysis in the logit regressions. We use variables describing adequate access to equipment, internet and technical support as well as sufficient skills, resources and teacher confidence as potential obstacles to ICT usage from both the teacher and principal surveys.

A second pair of regression models is estimated to explore the extent and importance of interactions between factors. This is estimated using a linear probability model (LPM) rather than a logit, because it is more straightforward to assess the significance of interactions in a linear model. In the LPM the factor variables enter the model as dummy variables. In all cases we allow for clustering of standard errors at school level to allow for possible correlation in unobserved effects at this level, which would otherwise lead to biased standard errors.

4. Results

4.1 Descriptive Statistics

The descriptive statistics provide an interesting insight into the differences in attitudes and perceived obstacles for the whole school sample. Looking at the 436 second-level schools

together, of which 50% are in group 1 and 50% in group 2, there is good variation across all school types and school sizes broadly reflecting the national sample of schools. Table 3 shows some main descriptive statistics of the dummy variables included in our model. 30% of the sample have DEIS status, this is a broadly representative sample with 26% of schools having DEIS status nationally. 45% of schools have e-learning plans of some description within their school and 19% of the schools had broadband connection speed below 10Mbps prior to the broadband rollout.

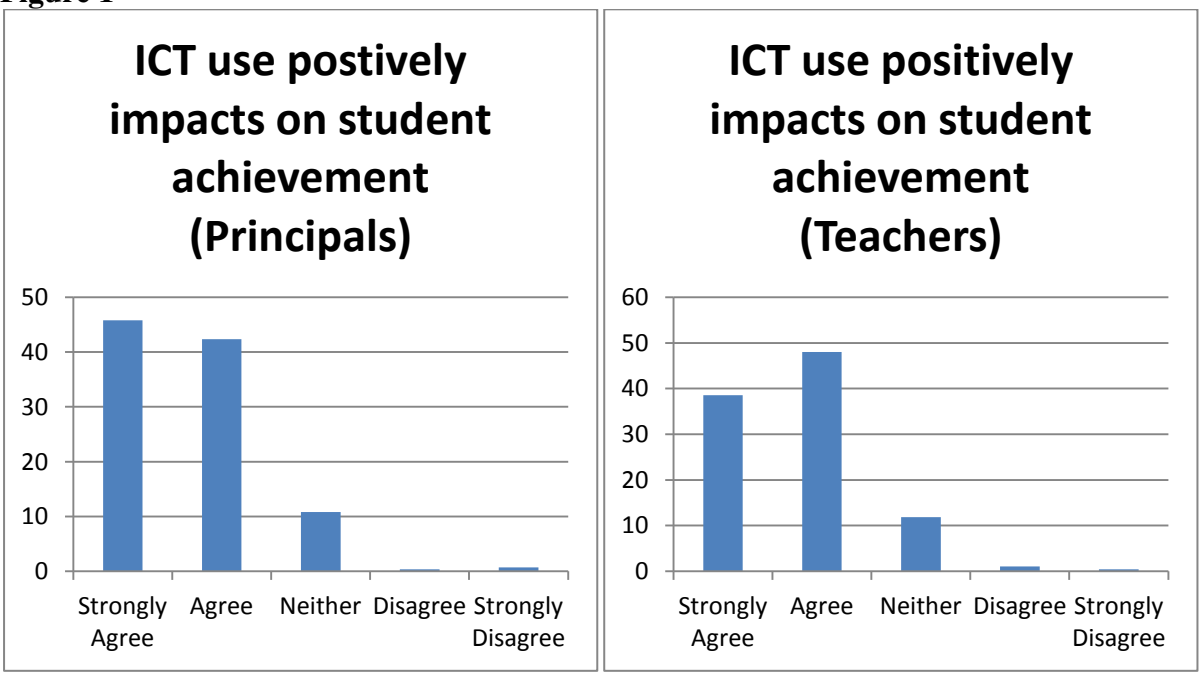
Only 7-10% of teachers have engaged in an internet training course in the last two years, 37% have taken a course on the pedagogical use of ICT and most training taken was provided by a member of staff with 50% of teachers taking part in this in the last two years. In total 36% of teachers stated that students frequently or always use internet in their classroom in teaching their main subject and 33% of teachers stated that their students frequently or always used ICT in teaching their main subject to reinforce or practice routine skills and procedures. A large proportion, 60%, of teachers uses ICT to support their teaching and teaching outcomes in different ways. Using ICT to support learning and learning outcomes is relatively less common with 29% of teachers frequently or always using ICT to support learning in different ways. Less traditional methods of using ICT in education such as communicating with students and parents via email, publishing students' work online, using social networks in class, collaborating with other teachers and experts etc. don't currently feature largely with teachers in these schools.

Table 3: Descriptive Statistics

Variable	Obs (total)	Sample Share (%)
Support for teaching	868	59.79
Support for learning	868	28.92
Group 2 school	868	50.12
E-learning plan in place	555	45.41
Special needs (>25% of children)	868	14.40
DEIS status	801	29.59
Connection speed >10Mbps	750	80.53
Professional Development Training	868	39.06
Introductory internet training	868	6.68
Intermediate internet training	868	9.79
Advanced internet training	868	10.02
Equipment-specific training	868	41.94
Pedagogical use of ICT training	868	36.64
ICT training provided by school staff	868	49.65

Attitudes to ICT are consistently positive across all subgroups of the schools. Figure 1 shows 89% of principals and 87% of teachers agree or strongly agree on ICTs use in teaching and learning positively impacting on student achievement. The strong positive attitude towards ICT use in teaching and learning is also present in 95% of teachers agreeing that ICT is an important tool for teachers and 77% agree or strongly agree that ICT has changed the way they teach.

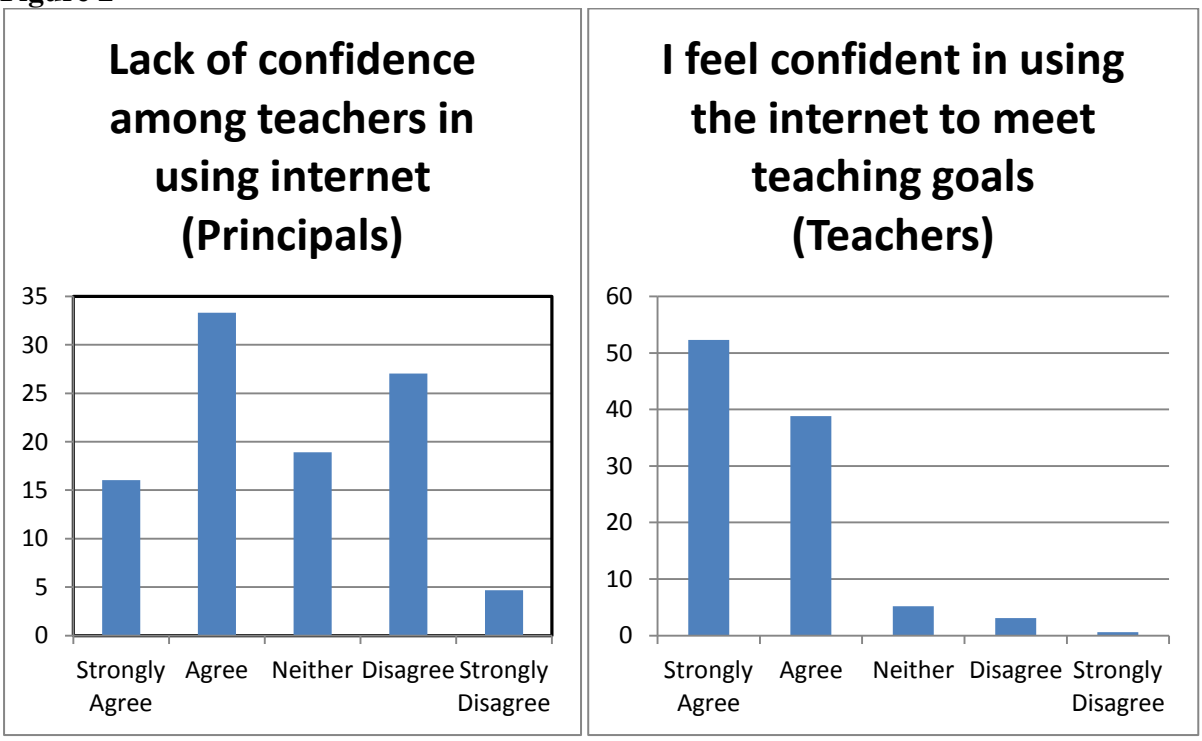
Figure 1



Nevertheless, perceived barriers to ICT usage differ significantly both between subgroups of schools and between principals and teachers. There is considerable variation across principals in their perception of barriers to ICT usage; inadequate equipment or internet provision, inadequate technical support, inadequate skills of teachers and teachers' confidence. Figure 2 illustrates a difference between teachers' and principals' perception of teachers' confidence in using ICTs. In total 49% of principals agree or strongly agree that lack of confidence among teachers using the internet acts as a barrier to ICT usage. However, 91% of teachers agree or strongly agree they are confident in using the internet to meet teaching goals. Similarly, 78% of teachers rate their knowledge of how to use the internet and computers in teaching their main subject as good or very good. Technical support emerges as a significant obstacle with only 36% of teachers agreeing or strongly agreeing there is adequate technical support in the school, this is similar to principals with 28% agreeing or strongly agreeing that

there is adequate technical support within the school. 42% of principals and 44% of teachers agree or strongly agree there is adequate internet access for both students and teachers.

Figure 2



We estimated multivariate regressions in order to investigate the significance of these perceived obstacles as well as the various school and teacher characteristics. As noted earlier, since we are purely working with cross-sectional data we cannot infer causation from these models. However, multivariate analysis does allow us to identify associations in the data while holding other factors constant.

Table 4 contains the logit regression results presented in odds ratios where a number greater than one signifies a positive association and less than one signifies a negative association with our dependent variables. Professional development training (PDT) has a marginally significant negative association with use of ICT supporting teaching however all the other significant training variables have a positive association with ICT usage in supporting learning, and intermediate training courses have a positive and highly significant association with use of ICT to support teaching. This positive association is what we would expect from specific teacher training courses. The negative association of greater than 3 days general PDT training within the last two years relative to less than 3 days could indicate that the extra days

of training are not encouraging further use of ICT in teaching without other supporting factors or that additional training makes teachers more conscious of the practical constraints they face in their schools.

All significant school size variables have a negative association of use of ICT in supporting teaching relative to the reference category of very big schools. This supports the notion that economies of scale are present in the facilities and supports usage of ICT. Female teachers significantly increase the likelihood of using ICT to support teaching compared to male teachers. Teachers whose main subject is Maths has a negative association with using ICT to support teaching, this result is in keeping with Machin *et al.*'s (2006) paper. Surprisingly, the more highly teachers' rated their own knowledge of how to use computers and the internet in teaching their main subject, the less likely they are to use ICT to support their teaching. Similarly, the more confident teachers rate themselves in using ICT the less they are using ICT to support teaching. 'Adequate ICT resources' has a negative association with using ICT to support learning. Use of ICT to support learning significantly increases the likelihood of using ICT to support teaching and vice versa.

Table 4: Logit regression results in odds ratios for current use of ICT in supporting teaching and learning, clustered at school level.

Dependent variable	Support for teaching	Support for learning
Teacher_female	1.932***	0.805
Principal_female	0.756	1.123
Teacher_Age	0.900	1.106
Principal_Age	0.966	1.056
Teacher_experience	0.869	0.922
English Teacher	1.815	0.739
Science Teacher	1.119	0.920
Maths Teacher	0.471**	0.888
Other Teacher	REF	REF
Girls Secondary Schools	1.082	0.511*
Boys Secondary Schools	0.778	0.407*
Co-educational Schools	0.844	0.564
Community/Comprehensive Schools	0.809	0.547
Vocational Schools	REF	REF
Small Schools	0.407*	0.999
Medium Schools	0.564**	1.620
Big Schools	0.482**	1.159
Very Big Schools	REF	REF
DEIS status	1.381	1.314
Group 2 school	1.198	0.791
Special needs	0.790	0.854
E-learning plan	0.753	1.155
Connection Speed >10 Mbps	0.597	1.136
Introductory internet training	2.103	2.446*
Intermediate internet training	2.454**	0.846
Advanced internet training	0.767	2.129*

Pedagogical training	1.000	1.693*
Equipment training	1.182	0.730
Within-school training	1.063	1.684*
Professional development training (PDT)	0.592*	0.835
ICT knowledge (teacher)	0.471***	0.806
Adeq. ICT resources (teacher)	1.095	0.786**
ICT confidence (teacher)	0.603**	0.808
Adeq. Tech. Support (principal)	1.058	0.924
Adeq. Equipment avail. (principal)	1.132	0.859
Adeq. Internet access (principal)	0.932	1.151
Sufficient_skills (principal)	0.914	1.203
Sufficient_resources (principal)	0.846	0.913
Household broadband internet access	0.211	2.133
Support for learning	1.543**	-
Support for teaching	-	2.068***
cons_	118.466***	0.070
N	443	443
R^2	0.20	0.17
* indicates significance at 10% level, ** at 5% level and *** at 1% level.		

The negative associations between confidence and knowledge of ICT and use of the internet in supporting teaching are not consistent with our expectations or the findings of previous literature. However, from previous research it's evident that many variables interact with each other to support ICT integration. In order to dissect such effects, we include interaction terms in the next stage of the analysis. Table 5 shows the significant results only for the interacted models. Coefficients are linear and therefore directly relate to the proportion of teachers using ICT in teaching and learning respectively.

Table 5: LPM results presented as linear coefficients clustered at school level (insignificant explanatory variables omitted from the table)

Dependent variable	**Support for teaching**	**Support for learning**
Teacher_female	0.091*	
Maths Teacher	-0.184***	
Girls Secondary Schools		-0.144*
Boys Secondary Schools		-0.178**
Co-educational Schools		-0.137*
Small Schools	-0.231**	
Medium Schools	-0.095*	
Big Schools	-0.151***	
Connection speed		0.418***
Intermediate internet training	0.147*	
Advanced internet training		0.187**
Pedagogical training		0.097**
Within-school training		0.084*
ICT knowledge (teacher)	0.279***	
ICT confidence (teacher)	0.305**	0.213**
Adeq. ICT resources (teacher)		0.175**
Sufficient_skills (principal)	0.168*	
Sufficient_resources (principal)	0.200*	0.316***
Adeq. Tech. Support (principal)	-0.227**	
Adeq. Equipment Availability (principal)	-0.229**	

Adeq. Internet Access (principal)	0.212*	
Support for learning	0.157***	-
Support for teaching	-	0.132***
Conn.Speed* Sufficient resources		-0.347***
Conn.Speed* Sufficient skills	-0.229**	
Conn. Speed*Adeq. Equipment avail.	0.232*	
Conn. Speed* Adeq. Internet Access	-0.211*	
E-learning plan* Confidence (teacher)	-0.281**	
E-learning plan* Adeq. Tech support	-0.188*	
E-learning plan* Adeq. Internet Access		-0.175*
Group 2* Adeq. Tech. support		-0.231*
DEIS * Confidence (teacher)	-0.241*	
DEIS* Adeq. ICT resources (teacher)		-0.207***
DEIS* Sufficient skills	0.284**	
DEIS* Adeq. Internet access	0.229**	
Special needs* Confidence (teacher)		0.294***
Special needs* Adeq. ICT resources (teacher)		-0.199**
Special needs* Adeq. Tech. support	0.241*	
Special needs* Adeq. Internet access	0.199*	
Special needs* Adeq. Equipment avail.	-0.224**	0.239*
Special needs* Sufficient skills		-0.356***
Introductory training* Confidence (teacher)	0.540***	
Introductory training*Adeq.ICT resources (teacher)		0.360**
Introductory training* Sufficient skills	0.405***	-0.412**
Intermediate training* Adeq. Tech. support		-0.437***
Advanced training* Confidence (teacher)		-0.575***
Pedagogical training* Sufficient resources		0.179**
Pedagogical training* Adeq. Equipment avail.		-0.175*
PDT* Confidence (teacher)		-0.409**
PDT* Adeq. Tech. support		0.198**
PDT* Adeq. Equipment avail.		-0.213**
N	449	449
R^2	0.23	0.18
* indicates significance at 10% level, ** at 5% level and *** at 1% level.		

On inclusion of the interaction terms we can see that the training marginal variables retain their significant positive association with use of ICT supporting teaching and learning. In addition, adequate ICT resources as stated by the teacher, teacher confidence and knowledge of how to use ICT in their main subject change sign on inclusion of the interaction terms and have a significant positive association with use of ICT in teaching and learning. These positive associations are as expected and in line with previous literature.

Interestingly, including interaction terms shows connection speed to have a significant positive association with using ICT to support learning. The coefficients on the connection speed interaction terms, however, show some surprising negative associations with ICT usage; a higher connection speed and sufficient skills, sufficient resources and adequate internet access are associated with lower incidence of using ICT to support teaching and learning. A higher connection speed and adequate equipment availability has a positive

association with ICT use to support teaching, which is as expected. While the presence of an e-learning plan isn't significant on its own, the presence of an e-learning plan interacted with teacher confidence, adequate technical support and adequate internet access is associated with a lower likelihood of using ICT to support teaching. This is not what we would expect. However, this is a case where causation may be complex: schools with limited technical support, internet access and teacher confidence may feel they should engage more actively in planning activities to overcome these constraints.

On school composition, schools with DEIS status and sufficient teacher skills or adequate internet access as stated by the principals have a significant positive association with using ICT to support teaching and learning. However, schools with DEIS status and adequate ICT resources or teacher confidence both as stated by the teacher have a significant negative association with using ICT to support teaching and learning. This relationship is difficult to explain; we may simply have to wait for post-upgrade data to make sense of this result. Schools that have many children with special needs and adequate equipment (as stated by principals) have a positive association with using ICT to support learning; however, a high level of special needs with adequate resources as stated by the teacher has a negative association. Similarly, a high level of special needs and sufficient skills as stated by principals has a negative association with ICT supporting learning but the opposite sign when these variables are assessed by teachers. Special needs and principal-stated adequate technical support and internet access have a positive significant association with ICT use to support teaching; however, special needs interacted with adequate equipment availability has a negative significant association. Again these relationships are unexpected, longitudinal phases of the study will hopefully help to explain differences across schools.

The internet training interaction terms have a significant positive association with using ICT to support teaching but have mixed results for supporting learning. Introductory internet training courses and teacher sufficient skills as stated by principals have a negative association with using ICT to support learning however introductory internet training courses and adequate ICT resources as stated by the teacher have a positive association with using ICT in supporting learning. This could indicate that ICT is being used in simple ways and that adequate resources are the key to enabling the use of ICT. Pedagogical training courses with sufficient resources have a positive association with use of ICT to support learning. This result is as expected. However, a surprising result is the negative association between training

courses in the pedagogical use of ICT and adequate equipment availability. We also found that advanced training courses with teacher confidence and intermediate training courses with adequate technical support has a negative association with using ICT to support learning which are counter intuitive. PDT interaction terms offer similar counter-intuitive results; PDT of more than 3 days in the last two years in conjunction with teacher confidence or with adequate equipment availability has a negative association with ICT use supporting learning. PDT and adequate technical support, however, has a positive significant association with using ICT to support learning.

5. Discussion and Conclusions

The pre-upgrade survey data shows that most teachers are positive about the impact of ICT and usefulness of ICT in supporting their teaching, which is reflected in their frequent use of ICT to prepare lessons for class. However, the use of ICT to date appears to be largely outside of the classroom in more effectively preparing for their lessons; teachers' state a much smaller proportion of students use ICT within the classroom. Approximately half of teachers use ICT to support different learning styles and 39% to support students' own-pace learning. This supports Gleeson *et al.*'s (2000) findings that teachers are using ICT to enhance their existing pedagogies but are not yet fully exploiting the potential of ICT for innovative teaching practices that could provide a wide range of learning outcomes. A report by the OECD states that for the best results, instead of using ICT in a traditional context, effective use of ICT entails innovation and change at all levels of the school environment (OECD, 2001). In order to achieve these gains any investment must be complemented with policies aimed at effectively embedding the internet in the education system (Belo, Ferreira and Telang, 2011).

There is some variation in perceived barriers to ICT usage across the sample. From the composition of our two outcome variables we might infer that using ICT to support teaching may largely be done outside of the classroom in preparation for class while less ICT is used within the classroom. Using ICT to support learning, however, would more likely require the students to use ICT within the classroom. The difference in these two outcome variables will likely highlight differences in obstacles faced by teachers. Sufficient resources and teacher confidence have a positive association with ICT use in both teaching and learning, but

connection speed is only significant in its association with ICT in supporting learning. We can understand why a faster connection speed would be vital to the use of ICT within the classroom but maybe less so outside of the classroom in lesson preparation.

Descriptive statistics on e-learning plans emphasise the important role of planning and the whole school approach in integrating ICT. E-learning plans are associated with significantly greater usage of ICT and more positive views of ICT value, of using ICT to support teaching and to support learning diversity. However, having an e-learning plan is not a significant variable in our multivariate regressions and the interaction between e-learning plan and confidence, adequate technical support, and adequate internet access have negative associations with ICT usage in teaching. This seems counter-intuitive and might suggest that causation runs both ways: some schools with limited equipment and connectivity may have tried to address their constraints by emphasising planning. The majority of training variable interaction terms have a significantly positive association with ICT use however there are some negative associations in the use of ICT to support learning. Again, this could reflect the need for many supportive policies to encourage the use of ICT within the classroom such as equipment and wifi access. The negative coefficients on connection speed interaction terms are surprising. This might reflect unreliability of pre-upgrade broadband connections regardless of speed that discouraged use of ICT, but we do not have data on this aspect of service quality. It could also be due to the complex mix of factors that influence ICT integration in the classroom.

School composition provides mixed results, while neither DEIS status nor high prevalence of special educational needs (SEN) are significant variables on their own, significance emerges through the interaction terms. Both DEIS schools and schools with a high level of SEN interacted with adequate ICT resources as stated by teachers have a negative association with use of ICT in learning. This may arise as most ICT that is used to support students with SEN is used more often by special needs teachers rather than mainstream teachers (DES, 2008), who were not surveyed in this phase of the study. However, there are still positive significant associations with special needs and DEIS status interacted with technical support and internet access in using ICT to support teaching and learning. Therefore, again it's possible that the right combination of supports is needed to encourage the integration of ICT in teaching and learning.

In conclusion, although attitudes to ICT are consistently positive across all subgroups of the sample our data shows that this has not necessarily translated into actual usage of ICT in the education system in the past. Focussing on teachers' current actual usage of ICT in teaching and learning, teacher training variables stand out as having a significantly positive association with current usage. The next stage of the study will consider the effects of implementation of high-speed reliable broadband with technical support for all second-level schools. Our study is a quasi-experiment and lacks a randomly selected control group of schools, but when the post-installation survey data are available we hope to exploit the time difference since installation of high-speed broadband in our two sub-samples to help isolate the effect that high speed broadband has on ICT usage within the school.

In future research it will be interesting to examine whether positive attitudes to ICT translate into actual usage and how barriers to ICT usage change after the connectivity constraint is relaxed. Connection speed's significant positive association with ICT usage in learning is a positive signal for the potential of this policy. Training will also likely play a large role in embedding broadband and ICT within teachers' pedagogical practices, increasing teachers' competence, skill and confidence in using ICT and achieving the desired teaching and learning outcomes. There are however, a number of further investments necessary to support this initial large investment in broadband connectivity and to achieve education policy objectives. As noted in Section 2 there are many structural issues that may discourage the use of ICT in the classroom such as rigid class timetables and structured syllabi for state examinations that inhibits pedagogies from incorporating ICT. These structural issues may become more prominent barriers to ICT use with universal high-speed broadband. However, Ireland has recently taken a step that may address some of these barriers by reforming the junior cycle state examinations towards continuous assessment with a large emphasis on project work (DES, 2014). The reform of the junior cycle involves "a shift away from an exam-dominated mode of assessment, less detailed curriculum specifications, fewer subjects to be assessed than currently, a focus on embedding key skills in teaching and learning, and a concern with more innovative approaches to teaching and learning" (NCCA, 2011).

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