Providing ICT for socially disadvantaged students

Technical paper

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Contents

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Executive summary

This literature review was carried out for CfBT Education Trust by researchers at the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) which is part of the Social Science Research Unit at the Institute of Education, University of London. The review addresses the following questions:

- Does the 'digital divide' exist for UK school students?

- Have interventions designed to enhance home ownership of ICT equipment for socially disadvantaged students had an impact on the students' subsequent academic achievement?

- Does home ownership of ICT appear to improve academic achievement?

The report summarises the results of what was a comprehensive literature review based on research identified through a systematic search of literature databases (carried out between January and April, 2012) supplemented by contacting experts in the field, and by 'snowballing' references identified in the literature. All identified studies were screened for relevance on abstract and titles, and some were further examined by full-text reports. Included studies were critically appraised in terms of methodological rigour and appropriateness, and their relevance to the review questions.

The three review questions are important in the present climate of curricular review and exam change and especially to schools who want to support socially disadvantaged students. Many claims for effectiveness have been made for ICT (Information and Communication Technology) and, given the level of investment in its use in education, the reviewers considered it important to examine whether those claims can be substantiated.

The review findings clearly indicate that there is little evidence of a digital divide in the UK. They suggest that lack of access to ICT is not really an issue for school students, particularly those who are socially disadvantaged. However, the research indicates that while ICT is often readily accessible, it is not necessarily being used in an effective way and from an educational point of view that may mean it is not being used effectively to enhance learning and increase attainment.

Although there is little evidence of a digital divide, access to ICT is, of course, still not universal, and the review looked therefore at evaluations of programmes that have provided socially disadvantaged students with free or discounted ICT equipment –with a view to identifying whether such interventions have an impact on educational attainment. Most of the studies included in the review showed only weak or variable effects from the programmes involved. The one large randomised controlled trial of high quality (Fairlie and Robinson, 2011) included in the review found no positive or negative effects from the free provision, but again this may indicate that it is not necessarily access that makes the difference but skill in using the resource effectively.

The literature available on home ownership of ICT similarly indicated that having greater access at home to the internet does not necessarily help raise a student's achievement at school.

The reviewers concluded that further research is needed, using large-scale data, to determine the way in which patterns of access and use of technology can affect educational outcomes, especially for socially disadvantaged school students.

1 Introduction

Ever since the home market for computers emerged in the 1980s there has been talk of a 'digital divide'. Increasingly, academic and policy efforts have focused on this concept, which describes divisions within and across societies between those who have access to digital technologies and those who do not (Eynon, 2009; Lichy, 2011; Livingstone and Helsper, 2007). For example, Chen and Wellman (2004) suggest the digital divide can be defined as 'differences between those who have all the necessary resources to participate in current society and those who do not' (Eynon, 2009: 277). In terms of the use of ICT in education, it is argued that access to technologies through schools, colleges, universities and at home is important for facilitating all kinds of learning purposes (Eynon, 2009). It has also been suggested that greater internet literacy is associated with more ICT opportunities being taken up (Livingstone and Helsper, 2007).

Much of the research on the digital divide has largely concentrated on adult populations and there is a paucity of evidence that addresses how children and young people access technologies (Devine and Lloyd, 2012; Livingstone and Helsper, 2007). Some researchers have argued that the lack of research on how children and young people access and use the internet is a result of their being 'widely perceived to be ahead, dubbed the internet generation or online experts' (Livingstone and Helsper, 2007: 672), which assumes all young people make use of available technology.

More recently, the digital divide debate has moved on from a dichotomy between the 'haves' and 'have nots' to a 'multifaceted phenomenon, defined as continuum of access and use where multiple interrelating reasons such as attitudes, skills, quality of access and social support are at work in explaining if, and how, people use new technologies' (Eynon, 2009: 278). This is what Lichy (2011) refers to as the 'second-level digital divide'.

In support of this new thinking, research has been concerned with comparisons across socio-spatial perspectives, such as along urban and suburban divides (Lichy, 2011) and between 'disadvantaged' and 'advantaged' socio-economic groups (Eynon, 2009; Lee, 2008; Livingstone and Helsper, 2007).

For schools and teachers, any digital divide has implications in terms both of their expectations of the technology knowledge that students bring to school and of what teachers can set for homework assignments. If, for example, some students do not have access to printers or the internet at home, this might impact on their ability to participate fully in school work. Similarly, if some students have better access to technology outside of school, this might put them at an advantage over those who do not. This prompts the question of whether the digital divide does still exist; and assuming it is socially disadvantaged young people who have less access to technology, what the implications of this might be for their educational attainment.

In addition to the question of access, the use of technology to boost educational performance has been urged on schools by various agencies including policy-makers and business. For schools with limited budgets and multiple demands it has become vital to ask if ICT equipment at home and at school makes it easier for students to learn, and whether ICT ultimately has an effect on educational attainment. In 2012 Nesta commissioned a review of the use of technology in the classroom and found strong evidence of a positive impact on learning, although the review notes that the impact is often down to how the technology is used.

This report summarises the results of a comprehensive and systematic research review (carried out between January and April, 2012) which initially sought to address the following questions:

- Does the 'digital divide' exist for UK school students? The review sought to explore whether the digital divide is a myth, as some researchers think.

- Have interventions designed to enhance home ownership of ICT equipment for socially disadvantaged students had an impact on the students' subsequent academic achievement? The focus of the literature to date has been on the impact of greater access in the classroom on educational achievement. This review sought to explore the evidence on how giving students who were socially disadvantaged access to ICT might impact on attainment.

During the literature search the team found studies that considered the relationship between self-acquired ICT equipment and school students' academic outcomes. It was decided to include these studies as they were relevant to both the question of a digital divide and the question about provision of technology access. Thus the review incorporated a third question:

- Does home ownership of ICT appear to improve academic achievement?

The three review questions are important in the present climate of curricular review and exam change – especially to schools who want to support socially disadvantaged students to match the academic results of their more affluent peers. Many claims for effectiveness have been made for ICT, and market forces have a vested interest in findings that support free provision. However, if free technology provision does not improve academic results, money might be best invested in other, more effective, areas of student support.

2 Defining what to review

To consider what research was eligible for inclusion in the review the researchers defined *socially disadvantaged* students as those meeting the EU social inclusion indicator of relative poverty (60% or less of the median income[1]) or those eligible for free or reduced-price school meals. They also included studies of students who were characterised as having low socio-economic status and those where multiple factors indicated social disadvantage, most notably living in a poor area with a low household income and with parents without higher education.

The reviewers did not include studies only about students with learning difficulties, but did include studies of looked-after children (in foster, residential or kinship care) as this was seen as a clear *social disadvantage* on more than one variable. Ultimately, the definition of social disadvantage had an economic focus rather than demographic or other possible variable.

Access to ICT was defined as access to computers, the internet, mobile phones and any other communication or learning device, with the main focus on computers and the internet as the most commonly used technologies in education and homework. ICT *provision* was defined as provision of free or discounted computers, mobile phone devices (e.g. smartphones), wi-fi or internet access. That access had to be provided to individuals, in the home, school or the community with the aim of improving their academic outcomes. The reviewers did not include studies relating to technology used for group teaching, such as interactive whiteboards, or studies on entertainment technology such as games consoles and home cinema devices.

The main question driving the review was: **What is the educational impact of interventions that provide free home technology access for socially disadvantaged students?**

On that basis, the review then followed this sequence. The researchers:

- identified studies which had evaluated the effect of ICT support interventions delivered to socially disadvantaged children and young people aged 5–16 from an OECD country[2] (but focusing, where possible, on studies from the UK)

- identified evidence on the extent to which a 'digital divide' exists amongst UK school students

- critically appraised all relevant studies and synthesised them.

The reviewers were keen to be transparent in order to facilitate future updates and critical appraisal of the decisions made during the reviewing process, so details about their review methodology were laid out in review protocols which related to every individual review question, and are included in this report as an appendix. A summary of the key information on what kinds of studies they searched for is provided in the following section.

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[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/conferences/documents/34th_ceies_seminar_documents/34th%20CEIES%20Seminar/1.1%20%20I.%20MARX.PDF
[2] OECD is an international economic organisation of 34 countries founded in 1961 to stimulate economic progress and world trade. A list of the 34 countries can be found at: http://www.oecd.org/general/listofoecdmembercountries-ratificationoftheconventionontheoecd.htm

3 Key information on the material reviewed

The review included any study of free ICT provision for socially disadvantaged students, such as free laptops, increased numbers of computer lessons per week, more accessible computers at school, and improved internet access at school or at home, with the intention to improve their educational attainment. The technology had to be provided with the specific aim of improving socially disadvantaged students' educational achievement. Interventions could focus on improving attainment in any subject area, but the focus was on attainment across the curriculum, not on ICT education itself.

The search found plenty of material focusing on schools in disadvantaged areas which had been part of some kind of 'technology immersion programme', where all students, teachers and classrooms were provided with technology access, and technology was used in teaching. However, because these studies evaluated an all-school approach to technology access they had to be excluded from the review.

In looking for evidence of the UK digital divide, the researchers approached the studies in a slightly different way. They realised that socially disadvantaged young people might not be the main focus of studies examining ICT access in the UK, but that the group might be part of a larger study. Therefore, the first sweep for material was for studies on family or household access to ICT, or with a focus on access *within socially disadvantaged areas or localities*. These essentially geographical studies were then further examined for data on the target population.

Similarly, the research team also found several studies which had considered the relationship between young people's *home* access to ICT and their academic achievement. These studies were included and examined for sub-group analyses on socially disadvantaged students.

One of the most interesting issues the team discovered as they started to review studies was that it became clear that some evaluations had not considered 'hard' outcomes such as test results, but used self-, parent- or teacher-reported perceptions of achievement. Others simply collected data on homework patterns. The team felt that although these did not measure what they were most interested in, they should be included because of their closeness to 'harder' outcomes such as literacy and numeracy tests. Outcomes also had to be school-related to be included; although secondary outcomes such as behaviour or creative learning may be relevant to schooling, they are not in themselves educational outcomes.

Many studies measured patterns of computer and internet use following technology interventions and (while not directly relevant to the review) the team did take this into account in terms of how it related to an intervention's implementation and use.

All studies about home access or free provision were published in English, conducted in an OECD country and published after 2000. Studies on the digital divide had to be conducted in the UK and, because of the fast development in this area in terms of market access to cheap technology, the team only included studies from 2006 onwards.

In addition to evaluations of free provision, the team found studies which analysed the relationship between having a home computer and academic achievement. These studies researched the impact of personally-acquired ICT rather than ownership initiated by a technology intervention programme. The team retained these studies for analysis, because they were relevant both to the question about the digital divide and the connection between ICT use and academic achievement. In the final report, however, these studies were presented separately from the evaluations of free provision.

All studies were assessed against a set of pre-defined quality and relevance criteria. Specifically, studies to address the question of free provision had to have measured attainment in the targeted students *before and after* the introduction of the ICT intervention, or researched the relationship between provision of free computer or internet access and attainment in the targeted students. Studies did not need to have included a comparison group but the team's assessment process gave more weight to studies that did.

4 The research methodology

The researchers used electronic databases on the basis of their relevance to the review topic and their depth of coverage, and databases that are particularly good for identifying English language studies. The following databases were searched from January to April 2012: ERIC (Education Resources Information Centre), BEI (British Educational Index), ASSIA (Applied Social Sciences Index and Abstracts), LISA (Library and Information Science Abstracts), Sociological Abstracts, Technology Research Database, Child Data, Social Care Online, Bibliomap, SSCI (Social Science Citation Index), Scirus. In addition the team screened the website of the Department for Education (which includes the archives of the Department for Children, Schools and Families). The researchers also searched http://evidencebasedprograms.org/wordpress/ which is a US site supported by the Coalition for Evidence Based Policy, and http://ies.ed.gov/ncee/wwc/ which is the website of the US What Works Clearinghouse for educational research.

The researchers also contacted a number of international academic experts in the field and a leading international community of practice for ICT professionals in education and education policy, in order to identify appropriate literature for inclusion into the review.

In addition, for the question about the presence of a UK digital divide, the team searched statistical evidence from the Office for National Statistics (ONS) about UK internet access. Papers, articles and reports of major surveys conducted in the UK on ICT access were examined for relevant references. Identified papers were used to inform two systematic searches on Google Scholar and ERIC, which complemented the wider overall search described above.

All search hits were imported into EPPI-Reviewer 4, which is an electronic database system for managing systematic literature reviews used by the EPPI-Centre. A screening tool was developed to reflect the focus of the review and this allowed reviewers to assess study abstracts for relevance electronically.

Studies that were relevant to the question about free provision were given one of three codes: qualitative study, survey analysis, or an outcome evaluation. The latter study designs were of most relevance. Studies relevant to the UK digital divide were also identified during this process and coded in the same way.

The team aimed at being primarily inclusive rather than exclusive, and so any studies where the abstract was unclear, or where a second opinion was needed, were assessed on the full study report and by discussion with one another.

5 How studies were appraised

Assessment of the studies was based on the design and methods used, rather than their findings.

5.1 Quality appraisal of survey analyses on the digital divide

Studies that addressed the question about the UK digital divide were all analyses of survey data on ownership, access or use of ICT amongst different population groups. These studies were assessed on the following questions:

A. What is the relevance of the topic focus of the study to the review question?

B. Are the study methods and results sound?

C. Is this study type appropriate for answering the review question?

Answers to these questions were summarised to provide an overall assessment of the weight of the evidence.

5.2 Quality appraisal of evaluations of free ICT provision

Key characteristics of included studies were coded in EPPI-Reviewer 4 and focused on the population, intervention and outcomes measured, in addition to the study's design, data collection, analysis and relevance to the question about academic impact from free provision of ICT. The studies were then weighted in terms of robustness of methods and overall relevance, considering the questions below:

A. Are the study methods sound?

B. Is this study type appropriate for answering the review question?

C. What is the relevance of the topic focus of the study to the review question?

Following the EPPI-Centre's model for estimating the weight of the evidence, answers to the questions stated under A-C were counted and summarised into an overall weight of the evidence.

5.3 Quality appraisal of outcome evaluations

Studies that researched the relationship between home ICT access and academic achievement were assessed in a similar, but slightly different, vein. Because these studies did not directly apply to the review questions, but were used to provide further context to an area of limited research, the team did not assess these studies on their methods or appropriateness to the question. Instead, these studies were assessed on relevance and study quality only:

A. Scores on relevance were considered: whether the study aimed to compare children and young people from different socio-economic backgrounds and to examine the relationship between these groups in terms of their access to or use of home computers and their educational achievement, or whether socio-economic status figured as a sub-group or control in the analysis.

B. Study quality was assessed on sample size, the extent of the reporting on statistical differences and whether the study included a comparison group.

6 How studies were selected

The search strategy identified 1,903 individual studies which were screened for eligibility. The flow diagram of search hits (Figure 1 in the Appendix) shows the key stages in the screening process which resulted in the inclusion of eight studies on the digital divide, eight evaluations of free provision, and five survey analyses that researched the relationship between home access and academic attainment.

7 The review findings

The review aimed to address the following research questions:

1. Is there a digital divide in the UK?

2. Does providing free home ICT access to socially disadvantaged school students improve their academic attainment?

3. Does home ownership of ICT appear to improve academic achievement?

The findings reported below are organised according to the original review questions, as well as the additional question (no. 3) informed by the set of studies found which considered the relationship between self-acquired ownership of ICT and academic achievement.

7.1 Is there a digital divide in the UK?

The researchers identified eight studies relating to this question, which were critically appraised on their trustworthiness, value and relevance to the question of whether a digital divide exists for children and young people in the UK. The key characteristics of those eight studies are listed in Table 1 in the Appendix. These eight studies were weighted to assess their relevance and acceptable quality.

Relevance was scored 1 if the study was clearly about the digital divide and ICT access; 2 if it was about the digital divide or ICT access; and 3 if it was about neither.

Study methods scored 1 if the results could be extrapolated to the whole population (this was the case if the sample was UK or national and the sample size was greater than 300), if it was a quantitative study reporting statistical difference or effect sizes, and if the analysis included a comparison group. The study scored 2 if results could be extrapolated to the whole population and it reported statistical differences or effect sizes. All other studies scored 3 on methodological rigour. Appropriateness was scored on three scales of bias. Table 2 in the Appendix shows the results of this weighting.

That some studies were assessed as being of higher quality and relevance to the review question than others is further illustrated in Table 3 in the Appendix, which provides details on the studies' focus and results. Tables 2 and 3 show clearly that four studies were of higher relevance and quality than others, and the summary below is primarily based on these reports: Eynon, 2009; Lichy, 2011; Livingstone and Helsper, 2007; Ofcom, 2011.

Summary of findings

Although ICT can refer to a variety of technologies, a lot of the research actually concentrates on one particular technology: the internet. Even so, there is a dearth of national studies reporting on patterns of internet access and use, especially for children and young people. Additionally, the available research does not always consider the educational outcomes/attainment of using technology. Instead, the focuses tend to be on the possible inequalities in access and types of usage for different socio-economic groups (Eynon, 2009; Livingstone and Helsper, 2007), along socio-spatial lines (Lichy, 2011) or by child demographics (Livingstone and Helsper, 2007).

The studies indicate that access to ICT is almost universal for children and young people and has increased rapidly over the last few years. This has largely been driven by an increase of access within households with children. For example, Livingstone and Helsper's (2007) research based on a sample size of 1,375 young people aged 9–17 years showed that '74% of children and young people in this study accessed the internet at home' (p. 676) and that only 3% could be classified as 'non-users'. Also, Ofcom's report (2011) which aimed to give an overview of media use, attitudes and understanding among children and young people aged 5–15, showed that 'nine in ten (91%) children aged 5–15 live in a household with internet access via a PC/laptop'. They report this access to be an increase from 87% in 2010, which they argue has been driven by 'a rise in home internet access among [age] 12–15s (95% vs. 89% in 2010) and among [age] 8–11s (90% vs. 86% in 2010)' (Ofcom, 2011: 2). These findings are supported nationally by ONS statistics (2011) which report that 77% of households now have access to the internet (increasing from 73% in 2010) and 93% of internet connections are through broadband (ONS, 2011).[3]

The Ofcom (2011) study also reports on internet access through different types of media. This shows that a laptop is the device most often used to go online at home: 'while slightly more than eight in ten children (82%) use the internet at home through a PC or laptop, two in ten (17%) go online via a fixed or portable games console/games player, around one in seven (14%) via a mobile phone, one in fourteen through a portable media player (7%) and one in fifty through a tablet PC (2%)' (p. 25). However, the report goes on to state that overall, 'accessing the internet at home through other devices is very much in addition to accessing it through a PC/laptop' (p. 25).

Livingstone and Helsper (2007) found that lack of access was related to both socio-economic status (SES) and age, so that 'non-users are more likely to be found among the oldest age group [these are 18–19 year olds] and the youngest age group [these are 9–11 year olds], and they are most common among poorer households' (p. 676). Also, they found little, if any, gender difference for the younger-aged children in their study but a gender difference for young people in their early to mid-teens, 'by which time the number of opportunities taken up is expanding' (p. 686). However, they found that the observed SES difference (of less access by poorer households) disappeared when the young people with home access only were compared, which they argue shows that 'children from lower SES homes who have home internet access use it just as much as those from higher SES homes' and that 'providing home internet access helps to close the gap in use, potentially reducing disadvantage' (p. 678). This is supported by findings from Eynon's (2009) study which showed that 'in 2003, 53% of internet users had home access compared with 94% of internet users in 2007' and leads her to conclude that 'home access does have a significant role in explaining who uses the internet for some of these learning activities' (p. 8).

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[3] These findings are from the annual publication Internet access – *households and individuals*, which is derived from the National Statistics Opinions Survey, which samples people aged 16–65 and over in the general population.

The Ofcom (2011) study identified socio-economic differences in access and use. The Ofcom study compares socio-economic difference using the social grades A/B, C1, C2 and D/E. These groups are social grades of chief income earners derived from the British National Readership Survey (NRS).[4] The Ofcom study suggests that internet access at home in AB and C1 households is now close to universal (98% and 96% respectively) but home internet access for children in D/E households continues to be lower than the levels across all other socio-economic groups (Ofcom, 2011: 15). While in 2010 the Ofcom study (2011) finds no difference across household socio-economic groups in the device mostly used by children to access the internet, by 2011, children in D/E households were identified to be less likely than all children to mostly use a desktop PC (27% vs. 33%) and more likely to mostly use a mobile phone to access the internet (6% vs. 3%). The Ofcom study (2011) also reports difference by gender of the child. For example, boys aged 8–11 are more likely than girls of this age to ever access the internet at home via a fixed or portable games console/games player (25% vs. 13%).

Lichy's (2011) research explored the digital divide by comparing internet usage in France and Britain. She argues that while the internet is 'levelling the playing field' in terms of content and children's exposure to the breadth of uses, 'engaging in scholastic/educational activities online remains unequally distributed by social background in both France and Britain' (p. 473). However, she concludes that the survey data as a whole indicates that 'relatively few major differences in internet usage were identified between urban and suburban internet users' (2011: 473).

Livingstone and Helsper (2007) argue that long-term evaluations are needed in order to assess 'the consequences of differential internet use' (p. 683). They suggest that instead of comparing those who use technology with those who do not, a more helpful way of addressing the issue (especially for young people) is to conceptualise a 'continuum of use' (p. 682). They suggest two possible ways of mapping this continuum, one based on the amount of use (non-users, low-users, weekly, daily) and the second based on breadth of use, which refers to the range of opportunities taken up (p. 684). While home ICT provision has undoubtedly increased young people's access to the internet, Livingstone and Helsper (2007) suggest it can alleviate but not overcome the relative disadvantage of coming from a low SES household in terms of the breadth of internet use' (p. 692).

7.2 Does providing free home ICT access to socially disadvantaged school students improve their academic attainment?

This section explores the main objective of this report: to identify studies that *have* evaluated the academic impact of providing free technology access for socially disadvantaged students aged 5–16.

Summary of findings

The search for research on the effectiveness of interventions identified eight studies for inclusion in the review (Fairlie and Robinson, 2011; Finn et al., 2005; Harris, 2010; Jackson et al., 2006; Mouza, 2008; Sharp et al., 2003; SQW Ipsos MORI and London Knowledge Lab, 2011; Tsikalas et al., 2007). These studies differed in key characteristics, both in terms of interventions and study design, but all of them did indeed look at the impact of free technology provision on the achievement of socially disadvantaged young people. Because of these key differences, a meta-analysis of results was inappropriate and so what follows is a narrative synthesis.

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[4] The Ofcom research uses a 'social grade' classification system, which has six groups: A, B, C1, C2, D and E. More information on these grades can be located at: http://www.ipsos-mori.com/DownloadPublication/1285_MediaCT_thoughtpiece_Social_Grade_July09_V3_WEB.pdf . A/B=High managerial, administrative or professional and intermediate managerial, administrative or professional; C1=supervisory, clerical and junior managerial, administrative or professional; C2= Skilled manual workers; D/E=Semi- and unskilled manual workers and state pensioners, casual or lowest grade workers, unemployed and state benefits only.

Six of the studies were from the USA and two were from the UK. One study provided technology to children in foster care and was a family-wide intervention (Finn et al., 2005). The samples of five studies were predominantly children and young people eligible for free or subsidised school meals (Harris, 2010; Jackson et al., 2006; Mouza, 2008; SQW Ipsos MORI and London Knowledge Lab, 2011; Tsikalas et al., 2007). One study's sample was underperforming students (Sharp et al., 2003), although this study had limited information on their socio-economic status. The final study provided computers to those without home access (defined as socially disadvantaged in terms of low parental education) (Fairlie and Robinson, 2011).

Seven of the eight were prospective studies that had implemented a programme of free technology access and evaluated its impact on attainment or attitude to school or homework. One study was a retrospective survey which asked socially disadvantaged students for their views on their school's one-for-all laptop programme and compared their answers with those from students of higher socio-economic status (Harris, 2010). The studies are described in terms of their key characteristics and findings in Table 7 in the Appendix.

Most of the programmes provided free or reduced-priced computers and internet access along with support, but one study explicitly evaluated only the impact of access without support (Fairlie and Robinson, 2011). Seven studies evaluated interventions provided in family households, and one, Sharp et al. (2003), evaluated a community-based initiative. Although all eight set out to consider home access and impact on academic attainment, the actual outcome measures varied considerably. Some studies sought only for young people's perceptions of impact, and some focused more on learning and computer use than educational achievement in school.

While Table 7 links study results with key study characteristics, the team's analysis weighted the studies according to the soundness and appropriateness of their methods and each study's relevance to the review question. This was done in order to give a heavier weight to high-quality and relevant studies when considering what the team had already learned from the review, on the academic impact of free provision of technology to socially disadvantaged students.

Table 8 in the Appendix shows the results of the above appraisal and weighting of the evidence found. To achieve a 'high' ranking, a study had to be a randomised controlled trial or a study which compared results for the intervention group with results for a similar group, and have measured 'hard' data on achievement such as test results before and after the provision of free technology. To achieve a high ranking on relevance, the study's setting had to be similar to the UK, be clearly targeted at socially disadvantaged school students, provide free technology access and measure its impact on their educational attainment. As is clear from the table, no study scored 'high' overall, but Fairlie and Robinson (2011) was a high-quality study of medium relevance to the review question. The study was not of high relevance because its study sample consisted of students without computers at home, rather than socially disadvantaged students. Their data shows that their students did rank low on parental education, hence the 'high/medium' score.

In Table 8, studies are ranked so that the study with the highest overall score is listed at the top (Fairlie and Robinson, 2011) and the study of lowest relevance and quality is listed at the bottom. Those who achieved the same score are listed in alphabetical order.

As mentioned earlier, a problem with some studies was that they did not use 'hard' educational data but data such as students', parents' or teachers' *perceptions* of programme value, or changes in

amount of time spent on homework. Table 9 in the Appendix shows the studies left in when those that did not measure impact on academic test results were excluded.

As shown in Table 9, the study by Fairlie and Robinson (2011) was of much higher quality than all other studies, because it was a large randomised controlled trial which looked at impact on school administrative data. The overall findings of this study were that the free provision of computers did not impact positively or negatively on educational achievement. Two aspects are worth noting when considering these findings: a) school students recruited to the study were assessed for home ownership of computers rather than social disadvantage; and b) the intervention provided free computers only, without internet connection or additional technical support.

The US study by Jackson et al. (2006) was of medium methodological quality and high relevance, but lacked a control group. School students were targeted because they were perceived as socially disadvantaged, and were provided with free computers, internet and home technical support. Outcomes were measured on Grade Point Averages (GPA) for maths and reading. Overall, the GPA of the sample did not change in the time period. When controlling for race and looking at rates of internet use, the study found that there was no relationship between using the internet and GPAs after 6 months, but internet use did predict GPA after one year of home internet access and at the end of the 16-month trial. Use of the internet at 13–16 months of the intervention predicted reading comprehension and reading scores at the end of that time period measured on the Michigan Educational Assessment Program (MEAP) tests. More time online was associated with higher reading comprehension and total reading scores. No impact on maths was found on the MEAP tests. This finding mirrors that of the survey analyses that considered the relationship between 'naturally occurring' ownership and academic attainment (Fuchs and Woessmann, 2004; Judge et al., 2006; Notten and Kraaykamp, 2009; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010).

The study by Sharp et al. (2003) looked at a community support programme which set up ICT learning centres for underperforming pupils. Both the setting and the target group make it less relevant to this review than evaluations of home provision for pupils who were clearly socially disadvantaged. In terms of outcome measures this study was problematic because instead of a true comparison group they used results from a group recruited to a previous evaluation of the same study. Results are not clearly displayed in terms of the intervention and the comparison group but the study concluded that students attending the programme made greater progress in numeracy than students of the same age in the comparison group, and intervention students eligible for free school meals made greater progress than comparison students who were also eligible for free school meals. These differences in progress were not found for reading comprehension.

Only a small part of the evaluation of the English national intervention called the 'Home Access' programme (SQW Ipsos MORI and London Knowledge Lab, 2011) was relevant to this review. This is the pilot of Home Access in Oldham where attainment data was collected on students who had a Home Access computer and students who did not. All intervention students were eligible for free school meals, and the study was therefore highly relevant to this review. The authors themselves concluded that it is still too early to judge the educational impact of the programme, although they drew some conclusions based on overall changes in attainment nationally in the group eligible for free school meals. In Oldham there were some percentage differences between students who used the Home Access programme and those who did not, but it is difficult to draw conclusions because the figures are not clearly presented. For example we do not know achievement levels of Home Access users before they received the intervention, for example their predicted GCSE grades.

Finally, the work by Tsikalas et al. (2007) scored low on methodological quality but high on relevance. This study did not have a comparison group, and it was conducted by the providers of the programme, so it was not independent. The programme provided students with free computers and cheap internet access in addition to educational software in maths, science, social studies, reading and writing. Students and at least one carer or parent had to attend a workshop about how to use the software. This study found that frequency of home internet use was associated with standardised maths scores, again mirroring findings in survey analyses of 'naturally occurring' ownership and academic achievement (Fuchs and Woessmann, 2004; Judge et al., 2006; Notten and Kraaykamp, 2009; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010).

Of the five studies that measured outcomes on standardised tests or used administrative records of exam results, two studies of low methodological quality (in terms of measuring impact) found that the free provision of ICT was associated positively with students' maths scores (Tsikalas et al., 2007, Sharp et al., 2003). One study of medium methodological quality found that internet use predicted reading comprehension, but no overall impact from the intervention itself on the sample's GPAs (Jackson et al., 2006). Fairlie and Robinson (2011) report on a large randomised controlled trial which found no evidence of effect (Fairlie and Robinson 2011), while other studies have sometimes found an association in relation to one subject/skill but not to another (e.g. Jackson et al., 2006; SQW Ipsos MORI and London Knowledge Lab, 2011).

Considering these results alongside the quality of the studies reported above, it appears that there is no conclusive evidence as to the impact – positive or otherwise – of interventions to provide free computers to socially disadvantaged students on their subsequent academic achievement.

7.3 Does home ownership of ICT appear to improve academic achievement?

This section presents studies identified during the review which considered the relationship between self-acquired ICT equipment and students' academic outcomes. It is important to note, however, that these studies do not address the question of whether a programme of providing technology is a promising strategy for improving outcomes. They only consider the relationship between academic achievement and home ownership.

The screening process found eleven studies which were then critically appraised (Beltran et al., 2008; Borzekowski and Robinson, 2005; Fairlie, 2003; Fuchs and Woessmann, 2004; Judge et al., 2006; Notten and Kraaykamp, 2009; Osborne, 2007; Schmitt and Wadsworth, 2004; Thiessen and Looker, 2007; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010). The eleven studies were considered on their methodological robustness and relevance to the review question. Only studies that scored 'medium' or higher in the overall weighting of relevance and quality were included in the review. For transparency, all eleven studies are described in Table 4 in the Appendix.

After weighting and appraising the eleven studies, five were included in the review: Fuchs and Woessmann, 2004; Judge et al., 2006; Notten and Kraaykamp, 2009; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010. The results of the critical appraisal and weighting of these studies is displayed in Table 5 in the Appendix and the findings of the five included studies are displayed in Table 6 in the Appendix. The weighting that was derived compared school students from different socio-economic backgrounds and examined the relationship between these groups in terms of their access to, or use of, home computers and their educational achievement. This was combined with an assessment of methodological quality based on study sample, statistical estimates and the presence of a comparison group.

Summary of findings

All the five studies reported on research assessing the outcomes of what the research team refer to as self-acquired technology ownership. That is, technology that is privately acquired by family funds and not provided by a charity or government programme. All of the included studies report on analyses of large-scale quantitative data – four of the five studies are secondary data analysis of existing surveys or large-scale administrative data, collected for other purposes. Only one of the included studies, Thomson and De Bortoli (2007), reports on analyses of a new cross-national rolling survey that has been conducted since 2003.

The focus of all of five studies is on assessing the impact of home technology ownership on educational outcomes. Three of the five included studies (Judge et al., 2006; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010) explicitly set out to compare school students from different socio-economic backgrounds, either by comparing 'rich and poor', 'high poverty and low poverty' areas/schools and the 'digital divide' using socio-economic variables. The remaining two studies did not directly assess differences between socio-economic groups, as this was not the focus of their research. Instead they controlled for socio-economic differences in their statistical analyses, which does not provide results showing how the educational outcomes might compare between different socio-economic sub-populations of children and young people.

All five studies found significant association between access to and/or use of a home computer and improved educational outcomes, as measured by better results in maths and/or reading, or 'science-related domains'. Fuchs and Woessmann (2004) found that 'holding all other influences constant, the performance of students with internet access at home is statistically significantly better in math and reading than the performance of students without internet access at home' (p. 15). They also report significant differences in terms of the level of usage, with students performing much better if they use ICT (specifically webpages and email) 'between a few times a year and several times a month' or 'several times a week'. Similarly, Vigdor and Ladd (2010) found 'students with access to home computers tend to score about 2% of a standard deviation higher on reading and math test scores,' (p. 17) and Judge et al. (2006) found an overall positive correlation between home computer use and achievement in (third-grade) mathematics and reading.

In addition to directly measurable educational outcomes, the included studies report other outcomes that could be more broadly associated with education. For example, Notten and Kraaykamp (2009) found that parental attitudes to education and learning were associated with better performance of students in science. Parental attitudes were assessed by the number of books and other educational reading material in the family home. They identified an improvement in maths and reading for children and young people in homes with greater provision of books. Notten and Kraaykamp also reported positive results between computer access and improved performance in science subjects, leading them to suggest that 'children growing up in a household with computer access have a head start in school compared to their peers growing up in homes without computer access' (p. 378) and that 'parental investment in home computers seems to pay off in terms of more successful school performance of children' (p. 379).

However, not all outcomes were found to be significantly associated with home ICT ownership. Fuchs and Woessmann (2004) did not find an association with reading literacy. Some effects disappeared altogether when a range of factors (including parental education and parental occupation) were taken into account. Notten and Kraaykamp's (2009) study reports that 'including parental media resources in our model explains about half of the effect of parental socio-economic background.' (p. 378).

7.4 Were there any differences between sub-groups, specifically, for socially disadvantaged students?

Three of the five studies had an explicit aim of examining associations between technology access and/or use with educational outcomes for different socio-economic groups (Judge et al., 2006; Thomson and De Bortoli, 2007; Vigdor and Ladd, 2010). The key findings from these studies are reported below. None of these three studies were carried out in the UK but they are still of relevance and interest to this review because they present research evidence showing how ICT ownership and/or use differs between socially disadvantaged and non-socially disadvantaged students.

Thomson and De Bortoli's (2007) study reports on the extent to which technology access in schools, homes and other places was associated with educational outcomes, using data from the Programme for International Student Assessment (PISA) for 15-year-old Australian students. Part of this assessment included an analysis of the 'digital divide' in terms of technology access and use, between 'indigenous' and 'non-indigenous' sub-populations. Thomson and De Bortoli (2007) state that these findings are relevant because the indigenous population are on the whole economically poorer than the non-indigenous population of Australia. Thomson and De Bortoli (2007) found that 'compared to 70 per cent of non-indigenous students, only approximately half of the indigenous students have been using computers for more than five years' (2007:9). However, they found that indigenous students reported using educational software at home to a greater extent than non-indigenous students. For example, 23% of indigenous students using technology frequently (defined as 'Almost every day' or 'A few times each week'), also reported using educational software such as mathematics programs, compared with 10% of non-indigenous students.

Thomson and De Bortoli suggest that 'after accounting for socio-economic background, the performance advantage of having a computer at home remains significant' (p. 14). The authors found statistically significant differences in the 'performance advantage' of technology usage between indigenous and non-indigenous populations in four of the eight states: the Australian Capital Territory, Victoria, South Australia and Tasmania (p. 14).

The second study specifically comparing socio-economic groups was the Judge et al. (2006) American study. This study set out to explore technology access differences between students in high-poverty and low-poverty schools. Schools were classified by Judge et al. (2006) according to their concentration of children from low-income families, which they based on the percentage of total enrolment eligible for free or reduced-price lunches. The data of interest to the team was set out to identify if there were any differences between subgroups of students according to academic achievement in reading and mathematics within the low- and high-poverty concentrations. Three groups were compared: 'high achievers' (defined as children who were above the 66th percentile of the sample mean on reading or mathematics achievement), 'average achievers' (defined as children scoring between the 33rd and 66th percentile of the sample mean), and 'low achievers' (defined as those falling below the 33rd percentile). Within the 'high-poverty schools', Judge et al. found statistically significant differences between the three groups of students in terms of technology access and reading during third grade. A similar pattern was found in low-poverty schools. In both high- and

low-poverty schools, a greater proportion of 'low achievers' used technology for reading than did 'high achievers'. However, they found no such differences between the three groups of students in relation to their use of computers for mathematics (in the third grade).

Vigdor and Ladd's (2010) American research was the third study with the explicit aim of exploring the impact of differential ownership of home technology on educational achievement between socio-economic groups. They too used free or reduced-price lunches as their poverty metric. They analysed administrative data covering the population of North Carolina public schools between 2000 and 2005, during a period which they note was 'when home computer access expanded noticeably, and home high-speed internet availability rose dramatically' (2010: 4). Their main aim was to analyse the impact of home computer ownership and broadband internet on standardised test scores in maths and reading. Unlike the previous two studies, Vigdor and Ladd do not find many positive results associated with a 'broader expansion' of technology on test scores. In terms of socio-economic difference, they found that while the 'broader expansion of high-speed internet service has no association with test scores among students not participating in the subsidised lunch program', technology access does have a significant impact on those participating in the free or reduced-price lunch programme, with 'a reduction of nearly 3% of a standard deviation in the scores of program participants' (p. 25). They also found that broader expansion of computer access is associated with 'a reading test score reduction of 1.2% of a standard deviation among non-participants and 2.5% of a standard deviation among participants' (p. 25).[5] They then argue that their results suggest that the impact of initially introducing technology access and the broader expansion of high-speed internet 'is more negative among free and reduced-price lunch participants' (p. 25) as compared with students who were not in the free and reduced-price lunch programme.

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[5] Standard Deviation is a measure of statistical dispersion. It describes how spread out a value is from the mean (average) of that group. In this case, it is saying that reading scores were lower than the mean for non-participants and (significantly) higher than the mean for programme participants.

8 Conclusions

This review considered the research evidence in relation to three aspects of technology access and provision for socially disadvantaged school students. First, it assessed research on whether a digital divide still exists in the UK. Second, it assessed evaluations of programmes that targeted socially disadvantaged students with free provision of ICT to try to improve their academic achievement. Third, it assessed survey research on the relationship between having a home computer and academic achievement.

It is clear from the evidence reviewed that the digital divide debate goes beyond whether young people have or do not have access to technology. For example, while the evidence shows almost universal access for children/young people, there is also evidence of inequalities between groups of young people and their households, including differences by gender, age and socio-economic grouping. There do not seem to be any differences between urban and suburban areas (Lichy, 2011). However, Lichy calls for more research in this area 'to produce a framework that furthers the understanding of socio-spatial inequalities and internet use beyond national borders' (p. 474). There is therefore some evidence of a digital divide but it is more complex than just distinguishing between the 'haves' and 'have nots', and is therefore less about physical access to ICT and more about different kinds of usage. The paucity of good quality research in this area, particularly into how children and young people access and use technology, strongly suggests the need for more national studies to be conducted.

This review has considered evidence from evaluations of programmes that provided socially disadvantaged students with free or discounted ICT equipment. Unfortunately, most of the studies were carried out in ways that were methodologically flawed, while others indicate only weak or variable effects from the programmes involved. Therefore the review is inconclusive in terms of finding evidence for a direct impact on attainment of interventions to increase access to ICT for socially disadvantaged students. However, the one large randomised controlled trial of high quality (Fairlie and Robinson, 2011) included in the review found no positive or negative effects from the free provision; however, as indicated by other studies, it may not necessarily be access that makes the difference but rather how the ICT is used.

The findings of the randomised controlled trial included are important, because some research has suggested that free provision can have a negative impact on educational achievement; this review did not find any such evidence. Furthermore, providing students with home computers or internet access might have benefits beyond academic achievement, which have not been considered here. It is also worth noting that those studies that did find an impact on academic achievement related to programmes that provided more equipment than the large randomised trial, and many of them also provided technical assistance or support. Considering the digital divide found in terms of technology usage – with lower socio-economic groups less likely to use it for educational purposes – it might be that additional support can make a difference in terms of the impact of free provision. Further research is required in order to substantiate this.

The results of the review also indicate that targeted free provision of technology in schools needs to be considered in relation to whether schools expect students to have home access, and whether teachers encourage printed rather than handwritten assignments. Having a computer, printer and access to the internet at home could put those with access at a simple, practical advantage over

those without. If so, the inequality between access and limited or no access might appear in other areas than simple academic achievement, for example in terms of engagement with school and enjoyment of learning. Both of these are important aspects of students' school life.

Finally, in terms of the relationship between technology ownership/use and educational outcomes, particularly for socially disadvantaged students, there is a dearth of relevant large-scale research in the UK. Furthermore, much of the analysis in research that has been carried out is descriptive rather than causal. The team found only three studies examining the association between technology and education for socially disadvantaged school students, and all of them were outside the UK. Although these studies were not based on findings from the UK, they do provide evidence of how technology ownership within the home may be impacting on educational outcomes for children and young people from socially disadvantaged backgrounds in other English-speaking countries.

In terms of home access to ICT, the three studies identified focused specifically on socially disadvantaged students, suggesting poor access to ICT is associated with lower educational achievement for the most disadvantaged groups (Judge et al., 2006; Vigdor and Ladd, 2010; Thomson and De Bortoli, 2007). However, beyond initial provision, Vigdor and Ladd (2010) do not find many positive results associated with a 'broader expansion' of technology on test scores. It is not clear therefore whether it is access to technology *per se* that is causing any improvement or whether it is more to do with the ways in which children and young people are using computers. Further research is needed, using large-scale data, to understand how these patterns of access and use of technology may be impacting on educational outcomes, especially for socially disadvantaged students.

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Appendix

Figure 1: Overview of search hits

Identification

Records identified through database searching:
N=1983

Additional records identified through other sources:
N=34

Records after duplicates removed:
N=1903

Screening

Records screened:
N=1903

Records excluded: N=1868

Reasons for exclusions:
Not ICT provision N=1448
Population N=144
Not ICT for education N=60
Gender divide N=2
Not OECD setting or pre-2000 N=59
Qualitative study N=26
Commentary/Literature review N=25

About digital divide but pre-2000 and not UK N=104

Eligibility

Full-text articles assessed for eligibility
Evaluations N=13
Survey analyses N=11
Digital divide N=11

Full-text articles excluded: N=14

Evaluations excluded:
Study not available N=1
All-school provision N=1
Not about academic impact N=3
Survey analysis excluded: Low quality and relevance score N=6

Digital divide studies excluded:
Not about socially disadvantaged children and young people's access or lacking primary data (N=3)

Included

Studies included in synthesis
Evaluations N=8
Survey analyses N=5
Digital divide N=8

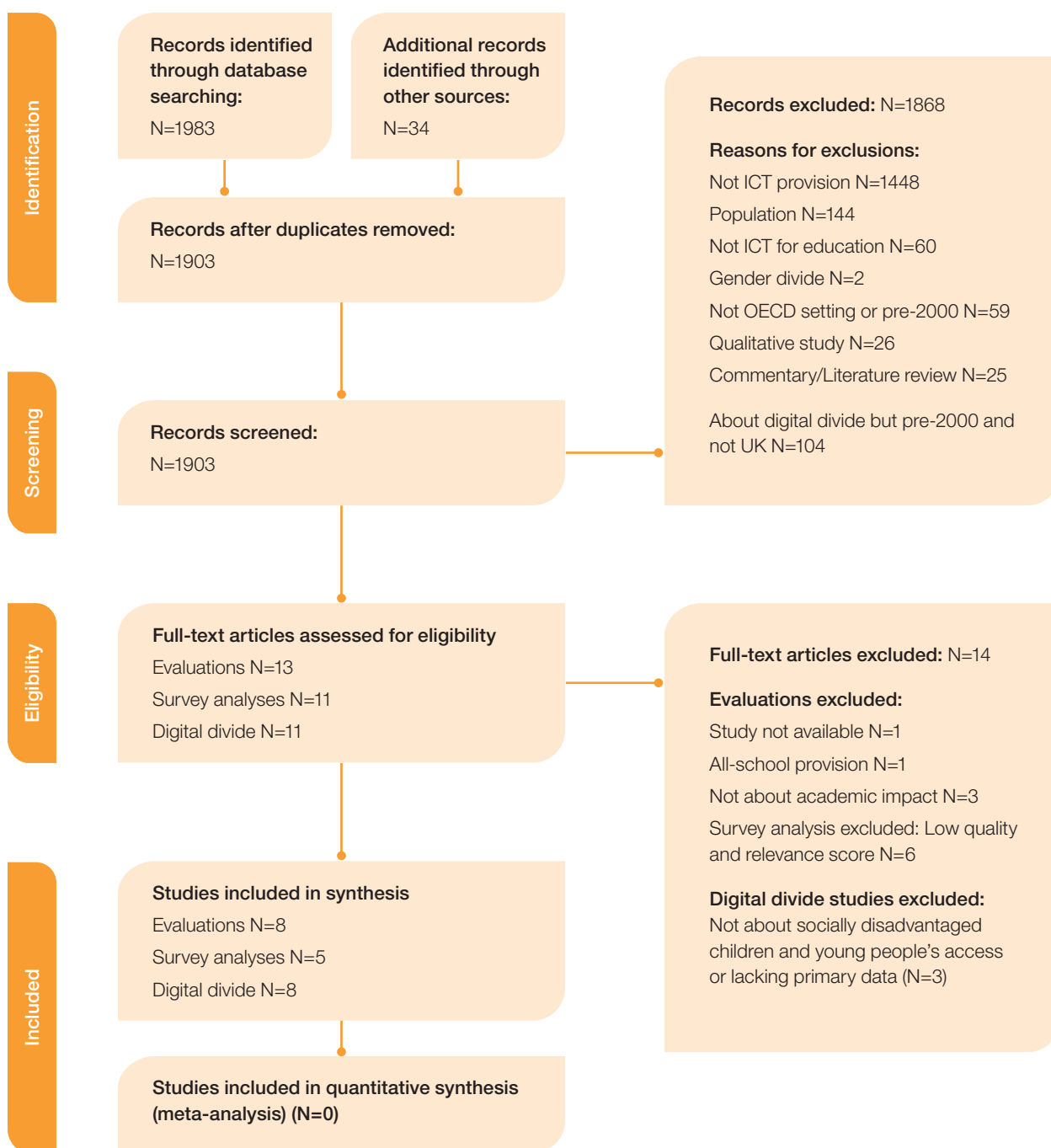Studies included in quantitative synthesis (meta-analysis) (N=0)

Table 1: Key characteristics of the eight 'identified' studies for research question 1:
'Is there a digital divide in the UK?'

Study reference	Mediappro (2006)
Study methods	Survey between 2005 and 2006
Sample age and size	865 secondary school students aged 12–18. No information found on how sampling was done.
National sample or regional?	UK-wide sample
Includes a control or comparison group? (y/n)	Yes – with other European countries
Types of analysis conducted	Descriptive – frequencies and crosstabs. No reporting of statistical difference. Descriptive cross-country statistical analyses.

Study reference	Devine and Lloyd (2012)
Study methods	2009 Kids' Life and Times Survey
Sample age and size	3,657 children aged 10–11 – 30% response rate. 100% sample – all primary schools in N. Ireland invited to participate.
National sample or regional?	Northern Ireland
Includes a control or comparison group? (y/n)	No
Types of analysis conducted	Descriptive analyses of: a) KIDSCREEN-27 instrument which assesses quality of life b) KLT questionnaire focusing on access to and use of ICT. Statistical differences are reported. Potential bias: results cannot be extrapolated to the population.

Study reference	Eynon (2009)
Study methods	Repeated analyses over time using surveys in 2003, 2005 and 2007
Sample age and size	Multi-stage probability samples of young people aged 14–17: 2030 in 2003 (66% response rate) • 2185 in 2005 (72% response rate) • 2350 in 2007 (77% response rate)
National sample or regional?	Oxford internet surveys of internet use in Britain. Nationally representative
Includes a control or comparison group? (y/n)	No
Types of analysis conducted	Factor analysis Bivariate analysis Logistic and linear regressions Reporting of statistical differences

Study reference	Becta (2008) (Bradbrook et al.)
Study methods	Two online surveys conducted in 2008 (learning at home and learning with the family), followed by three (family interviews).
Sample age and size	7,141 children aged 6–14 in total for the two online surveys. Drawn from population of 150,000 children across England who were members of an education networking site.
National sample or regional?	England
Includes a control or comparison group? (y/n)	No
Types of analysis conducted	Descriptive – frequencies and crosstabs. No reporting of statistical difference.

Study reference	Lee (2008)
Study methods	Online surveys conducted between 2000 and 2001.
Sample age and size	Four schools (strategically selected to include different socio-economic areas) from which 398 students aged 13–19 were randomly selected in five year groups.
National sample or regional?	Brighton and Hove
Includes a control or comparison group? (y/n)	Yes – comparison of four schools in different socio-economic areas and the socio-economic background of students within those schools.
Types of analysis conducted	Descriptive – frequencies and crosstabs. No reporting of statistical difference. NB: the comparative analysis was carried out using a social classification system developed for this study of three groups from upper to lowest socio-economic groupings: 'AB', 'C1C2' and 'DE'. 241/298 interviewed was grouped in 'AB', 91/298 interviewed was grouped in 'C1C2' and 45/298 interviewed was grouped in 'DE'. Potential bias: results cannot be extrapolated to the population.

Study reference	Lichy (2011)
Study methods	Survey of 10 questions: broad questions with sub-questions.
Sample age and size	585 responses from students aged 13–15 attending secondary schools in two distinct zones (marginalised neighbourhood and an affluent district) in Britain and France. Robust selection of schools: schools in each setting (Britain and France) were matched for size, academic results and absenteeism. Schools were chosen using government data from each country.
National sample or regional?	NE England (in Britain) and SE France
Includes a control or comparison group? (y/n)	Yes – with France. Comparisons are also made within countries between 'urban' and 'suburban' areas.
Types of analysis conducted	Largely descriptive but significant tests conducted and some reported – chi-square tests.

Study reference	Livingstone and Helsper (2007)
Study methods	National (face-to-face) survey: 'UK Children Go Online'
Sample age and size	1511 young people aged 9–19 sampled using random location sampling across the UK. Percentages have been weighted to data from BMRB's Target Group Index and Youth Surveys. The effective sample size was 1,375.
National sample or regional?	UK-wide sample
Includes a control or comparison group? (y/n)	No, but comparisons made between young people from different socio-economic backgrounds.
Types of analysis conducted	Descriptive and linear regressions. Significant tests conducted and reported.

Study reference	Ofcom (2011)
Study methods	Secondary analysis of Ofcom's 'Young People and Media Usage Survey' carried out over three waves in 2007. Review of Ofcom's 2011 study 'Children and parents: media use and attitudes report'.
Sample age and size	Draws on Ofcom's 2007 survey. Included in this review is the latest version (2011) of this survey, which is a UK-representative sample of 5–15 year olds. For the Holmes secondary analysis, 561 young people aged 12–15 who responded to specific home usage questions were selected for the analysis. The analysis sample excluded those without home access and also those who did not respond to these key questions at each wave of the survey in 2007.
National sample or regional?	UK-wide
Includes a control or comparison group? (y/n)	No
Types of analysis conducted	Ofcom report findings are from Ofcom's Media Literacy Tracker conducted in spring 2011. They include descriptive analyses of children's 'media literacy' (including a section on their 'take up of media') by child age, gender and household socio-economic group. No significance tests are conducted or reported. Holmes's secondary analysis of the 2007 Ofcom data comprises three stages of analysis: descriptive analyses to assess whether 'internet use is typically wide-ranging'; a 'step model' is constructed 'to assess the shared orientations approach' (this method counts the number of uses individuals put the internet to and reports the proportion engaging in a particular use for each number of usage); typologies are developed using latent class analysis (LCA) which is a cluster analysis technique suited to categorical data. Potential bias: all sample participants have home access – selected because they reported to have home access.

Table 2: Critical appraisal and weighting of the eight identified studies for research question 1, 'Is there a digital divide in the UK?'

Study reference	What is the relevance of the topic focus of the study to the review question?	Are the study methods and results sound?	Is this study type appropriate for answering the review question?	Overall weight
Mediappro (2006)	2	3	1	3
Devine and Lloyd (2012)	2	3	2	5
Eynon (2009)	1	2	1	2
Becta (2008)	2	3	1	3
Lee (2008)	1	3	2	3
Lichy (2011)	1	1	1	2
Livingstone and Helsper (2007)	1	2	1	2
Ofcom (2011)	1	2	1	2

Table 3: Key aims and results of the eight identified studies for research question 1, 'Is there a digital divide in the UK?'

Study reference	Mediappro (2006)
Study aims	To examine young people's use of digital media including the internet and mobile phones.
Key findings on ICT access	**P. 37:** 1) Nearly all pupils aged 12–18 (97.1%) said that they used the internet, with the majority going online daily or weekly. 2) While 79% of pupils indicated that they used the internet at least several times a week at home, only 59% of pupils said they used the internet with the same frequency at school. 3) Only 11.3% said they did not have internet access at home. 65.1% said they had access to a broadband connection. 4) 'Use of mobile phones by young people in the sample was nearly universal': 92.1% said they own their own mobile phone.
Key findings on the digital divide	N/A

Study reference	Devine and Lloyd (2012)
Study aims	To explore 'the availability and use of new technologies by children and the relationship between internet use and psychological wellbeing.'
Key findings on ICT access	1) 'Access to the internet and technology in general was very high among this cohort of 10- and 11-year-olds. As expected, most have mobile phones, computers and access to the internet' (p. 17). 2) P14: 98% respondents said their family had at least one computer and of these, 94% said these computers had an internet connection. 3) 97% respondents used the internet at school and 91% at home. 4) 86% used internet for school work and fun (9% just for fun and 4% just for homework). 'Girls were more likely than boys to say that they used the internet for school work and fun ($x2=32.372$; degrees of freedom [df] =1; p=0.001), whilst the reverse was true in relation to using the internet for fun alone ($x2=53.355$; df=1; p =0.001).'
Key findings on the digital divide	N/A

Study reference	Eynon (2009)
Study aims	To give 'a detailed picture of the digital divide in Britain, illustrating those who are non-users and users of the internet.'
Key findings on ICT access	**1)** From Table 1: 92% in 2003, 94% in 2005 and 90% in 2007 of young people aged 14–17 self-reported to be current internet users. **2)** Table 2 shows that being younger is positively related to being an internet user (B=−.028; p=<0.001). **3)** 'home access is not significant for using the internet for training and other formal learning activities' (p. 9) but the analysis does not offer a breakdown by age. **4)** Table 3 shows that 94% of young people aged 14–17 who report to be current internet users, use the internet for formal learning. Similarly, 92% of 14–17 year olds who report to be current internet users use the internet for fact-checking.
Key findings on the digital divide	'In 2003, 53% of internet users had home access compared with 94% of internet users in 2007... home access does have a significant role in explaining who uses the internet for some of these learning activities' (p. 8).

Study reference	Becta (2008) (Bradbrook et al.)
Study aims	To examine the nature of collaboration between parents and children in their use of ICT.
Key findings on ICT access	Key findings from the study on access: **1)** Most children (92%) had access to a computer and the internet at home. This corresponded to the findings of Becta's *Harnessing technology* review (2008), where 92% of parents of school-aged children said they had internet access at home. **2)** Most girls (94%) said they used a computer or laptop, compared with 88% of boys. **3)** On a typical school day, nearly six in ten went online as soon as they came home from school (58%). **4)** On a typical school day, children said they spent 79 minutes on the internet.
Key findings on the digital divide	N/A

Study reference	Lee (2008)
Study aims	To explore 'the significance of class membership among young people in the so-called internet age.'
Key findings on ICT access	1) 'All pupils except one out of 398 interviewed had used the internet, and most, irrespective of their socio-economic background, did so on a relatively regular basis' (p. 144). 2) 'rather than solely students' socio-economic status, it is gender, and also to an extent gender and lower socio-economic status, which appears to impact on lower levels of use and access to technologies' (p. 144).
Key findings on the digital divide	1) Poorer households were found to have less home access (p. 146) – Table 4 shows 33.3% of the poorest households (DE) had home access, compared with 61.5% of the middle socio-economic group (C1C2) and 92.5% in the top socio-economic group (AB). 2) The 'qualitative and socio-economically derived digital divide appeared to exist among students themselves, in part the result of the school they attended and the priorities and constraints within which the school needed to operate' (p. 146). 3) Concludes that 'class might not be a determinant of inclination or quality of use *per se*, but it does shape use because of the conditions in which different socio-economic groups act out their everyday lives, thus providing particular opportunities for use whether in quantitative or qualitative terms. Internet use therefore becomes inscribed with class through practices that may be related to inclinations and/or opportunities' (p. 150).

Study reference	Lichy (2011)
Study aims	To explore the concept of digital inequality in a cross-country setting, looking at internet use in different areas (urban vs. suburban) in France and Britain.
Key findings on ICT access	P. 472: 1) 'Respondents in each location can be described as heavy internet users.' 2) 'UK respondents overwhelmingly claimed that the internet had made schoolwork easier and that it was better for learning. The use of research sites (i.e. scholastic resources) was highest among suburban UK respondents (36%) and lowest among UK urban respondents (14%).' P. 474: 3) There is 'converging internet user behaviour', with French and British internet users aged 13–15 behaving 'very similarly online'.
Key findings on the digital divide	P. 473: 1) 'Although the internet is levelling the playing field in terms of exposure to content, the survey findings suggest that engaging in scholastic/educational activities online remains unequally distributed by social background in both France and Britain'. However, taken as whole, 'the survey data showed relatively few major differences in internet usage, either between urban and suburban internet users'.

Study reference	Livingstone and Helsper (2007)
Study aims	To examine the digital divide and assess inequalities in internet access and use by age, gender and socio-economic group.
Key findings on ICT access	**P. 676:** 1) There are few children who do not use the internet. 74% of children and young people in this study accessed the internet at home. 2) Most children use it daily (41%) or weekly (42%). 3) Only 3% were classified as 'non-users' – considerably smaller than the finding by Dutton et al. (2005) of one-third in the UK lacking access to the internet. 4) 'Gender, age and SES all matter to where and how young people gain internet access… the oldest and youngest groups have less home access than the younger and middle teenagers.' **P. 680:** 5) Young people who have access at home do not all use it. For these 'low users', the largest group are classified as the 'choose nots' (Table 7: 39/83). Of the low users aged 12–15, the largest group were classified as 'choose nots' (Table 7: 32/47) or 'marginal users' (Table 7: 30/47).
Key findings on the digital divide	**P. 676:** 1) Access is an issue of age and SES (though not gender): non-users are most likely to be the oldest age group (18–19 year olds), the youngest age group (9–11 year olds) and from the poorest households. **P. 678:** 2) '… age and gender differences persist, even when home access exists: boys and older teens use the internet more frequently than girls and younger children.' **P. 678:** 3) However, the SES difference (of less access by poorer households) disappeared when the young people with home access only were compared, showing that 'children from lower SES homes who have home internet access use it just as much as those from higher SES homes'… and 'providing home internet access helps to close the gap in use, potentially reducing disadvantage'. **P. 686:** 4) 'Among younger children, there is little if any gender difference. However, by the early to mid-teens, by which time the number of opportunities taken up is expanding, a gender difference has opened up.' **P. 687:** 5) 'for older teens, encouraging more internet use will result in the take-up of disproportionately more opportunities than it would for younger children' but this could be a developmental effect – older teens are more ready to benefit from internet opportunities. **P. 689:** 6) 'Girls use the internet in a greater variety of ways than boys at a younger age (9–15 years).'

Study reference	Ofcom (2011)
Study aims	Ofcom's report aims to: give an accessible overview of media use, attitudes and understanding among children and young people aged 5–15. Secondary analysis aims to 'explore two alternative perspectives: namely, continua of use and typologies of use'.
Key findings on ICT access	**Ofcom (2011) Executive summary:** **1)** Nine in ten (91%) children aged 5–15 live in a household with internet access via a PC/laptop, up from 87% in 2010. This increase is driven by a rise in home internet access among 12–15s (95% vs. 89% in 2010) and among 8–11s (90% vs. 86% in 2010). **2)** 43% of 12–15s have PC/laptop internet access in their bedroom compared to 14% of 8–11s and one in twenty (4%) of 5–7s. **3)** PC/laptop internet use at home ranges from 65% of 5–7s and 85% of 8–11s to 93% of 12–15s; an increase for this oldest group since 2010 (88%). As in 2010, around one in twelve (8%) of all 5–15s do not use the internet at all, in any location, with this varying considerably by age. Since 2010, children are less likely to use the internet on their own and more likely to use it in the presence of an adult. **P. 18:** 12–15s are now more likely to do so than in 2010 (93% vs. 88%). **4)** Since 2010 children aged 5–15 are more likely to live in a household with access to the internet through a PC or laptop (91% vs. 87%) and with a DVR (66% vs. 52%). A laptop is the device most often used to go online at home. **5)** In terms of internet use on a PC/laptop, 12–15s are most likely to use it for school work or homework or social networking; 8–11s are most likely to use it at least weekly for school work or homework; and 5–7s are most likely to use it for playing games. **P. 24:** **6)** While slightly more than eight in ten children (82%) use the internet at home through a PC or laptop, two in ten (17%) go online via a fixed or portable games console/ games player, around one in seven (14%) via a mobile phone, one in fourteen through a portable media player (7%) and one in fifty through a tablet PC (2%). The incidence of children accessing the internet through any of these devices increases with age. Use of a PC/ laptop to access the internet has increased since 2010 for 12–15s (93% vs. 88%), while using a mobile phone to access the internet has also increased for both 12–15s (29% vs. 23%) and 8-11s (9% vs. 4%). As might be expected, nearly twice as many parents of children aged 5–15 with a smartphone say that their child has ever accessed the internet through their mobile phone, compared to parents of children with a mobile phone (29% vs. 17%). Accessing the internet at home through a fixed or portable games player/console has not changed since 2010; accounting for around one in ten 5–7s (8%) and around two in ten 8–11s (19%) and 12–15s (23%). In 2011 children aged 12–15 who ever go online through a fixed or portable games console were asked whether this was mostly to play games online or to visit websites, with nine in ten of these children (89%) saying that they mostly play games online. However, overall, 'accessing the internet at home through other devices is very much in addition to accessing it through a PC/ laptop' (p. 25). (continued...)

Key findings on ICT access	There are no results about access *per se* and as all children in the sample had home access, there are no figures reporting who had home access compared with those who did not. However, the 'discussion' section on page 13 does state that 'a third of 12–15 year olds with home internet access are only loosely engaged with the internet and are likely to only make comparatively narrow use on a day-to-day or weekly basis'.
	The descriptive results mostly discuss types of internet usage. They show that:
	1) Children using the internet for homework 'are only significantly more likely to use the internet for email, games and information. Those who use the internet for information are more likely to engage in all activities, whilst those who use it for downloading music or listening to music are more likely to do everything but homework' (p. 10).
	P. 15:
	'Discourses of homogeneous context do not fit the reality that access and contexts of use (e.g. types of access) vary widely between young people.'
Key findings on the digital divide	**Ofcom report, p. 15:**
	1) Home internet access has increased for children in C1 households (96% vs. 92%) and in DE households (80% vs. 74%) since 2010, although home internet access for children in DE households continues to be lower than the levels across all other socio-economic groups. Internet access at home in AB and C1 households is now close to universal (98% and 96% respectively).
	P. 25:
	2) Boys aged 8–11 are more likely than girls of this age to ever access the internet at home via a fixed or portable games console/games player (25% vs. 13%), as are boys aged 12–15 compared to girls of this age (33% vs. 14%). Boys aged 12–15 are also more likely than girls to ever access the internet through a portable media player (16% vs. 9%).
	P. 26:
	3) In 2010 there were no differences across household socio-economic groups in terms of the device mostly used by children to access the internet. In 2011, children in DE households were less likely than all children to mostly use a desktop PC (27% vs. 33%) and more likely to mostly use a mobile phone to access the internet (6% vs. 3%). In 2011, children in DE households were less likely than all children to mostly use a desktop PC (27% vs. 33%) and more likely to mostly use a mobile phone to access the internet (6% vs. 3%).
	Additional analyses (not fully reported in the Holmes article) were carried out to assess whether age was a factor and altered the findings. 'The results showed that both genders and all age groups could be classified within similar typologies, although girls tended to make greater use of online communication whilst older users tended to be more extensive users' (p. 13).

Table 4: Study characteristics of survey analyses of children/young people, ICT access and academic achievement

Study reference	Fuchs and Woessmann (2004)
Study focus	To estimate the relationship between students' educational achievement and the availability and use of computers at home and at school.
Study methods	Secondary analysis of a cross-sectional student-level dataset of the Programme for International Student Assessment (PISA), an international student achievement test of 15-year-old students conducted in 2000 by the OECD.
Sample age and size	PISA sampled a representative random sample of the population of 15-year-old students using a two-stage stratified sampling technique. The sample size for the analyses reported in this paper is 96,855 students from 31 countries.
Includes a control or comparison group?	Yes: 30 other countries
Measures	Maths and reading scores. Computer use at school and home (home use is also used as a proxy of wealth to compare 'advantaged' and 'disadvantaged' students). Control variables include: student characteristics (gender, age, grade); family background (parental educational, migration status of father, mother and student, family status, parents' work status, parental occupation, number of books at home, school's community location and GDP per capita of country); 'resource inputs (e.g. class size, teacher education); and measures of Institutional factors (e.g. 'school autonomy in determining course content').
Types of analysis conducted	Bivariate analyses and multivariate regressions, with statistical results reported in tables.

Study reference	Notten and Kraaykamp (2009)
Study focus	**1)** To what extent can parental media resources explain differences in children's science performance? **2)** To what extent does a country's level of development affect the relation between parental media resources and children's science performance?
Study methods	Cross-sectional: data employed originates from the OECD Programme for International Student Assessment (PISA), conducted in 2006.
Sample age and size	345,967 students; 53 countries. The selection of students was based on two-stage random sampling: firstly schools were extracted, then respondents were selected. Nationally-representative samples of 15-year-old students were drawn.
Includes a control or comparison group?	Yes: cross-national comparisons.
Measures	Dependent variable, science performance is measured by scores on 108 science related tasks. Controls: child sex and age, parental socio-economic background (measured by parental educational level in years and occupational status). Parental media resources are measured by three specific types of media in the family home: books, television sets, and computers. Two variables at the country level represent the country's level of development (Gross Domestic Product and 'percentage of gross enrolment in tertiary education').
Types of analysis conducted	Assessment of cross-national differences in the effect of parental media resources using multilevel modelling. Possible bias: a drawback of the data is that enrolment rates in secondary school as well as drop-out rates are not equally distributed over all countries included in our study. 'Therefore, the students in our dataset might not be an accurate representation of the general population of 15-year-olds in a specific country when it comes to background characteristics and abilities' (p. 372).

Study reference	Thiessen and Looker (2007)
Study focus	Young people's use of ICT and its relationship to academic outcomes. Study aims to assess: **1)** the strength of the relationship between ICT use and a detailed, reliable measure of reading achievement, based on a nationally representative sample; **2)** the nature of this relationship (linear vs. non-linear), assuming it does exist; **3)** how the pattern of the relationship differs for females and males (p. 164).
Study methods	Cross-sectional: Cycle 1 of the Youth in Transition Survey/Programme for International Student Assessment (YITS/PISA) survey of 15-year-olds, conducted by Statistics Canada in 2000.
Sample age and size	A two-stage sampling design was used, with the first stage being schools (a total of 1,117) and the second stage being students within schools. The total sample size for students (all aged 15) was 29,687.
Includes a control or comparison group?	No
Measures	Frequency of ICT use; parental education; reading achievement.
Types of analysis conducted	Descriptive and regressions using hierarchical linear modelling (HLM).

Study reference	Osborne (2007)
Study focus	Investigation into the impact of an online revision tool, SAM Learning, on GCSE results in several local authorities (LAs). Key aims were to assess: **1)** Is using the tool associated with higher GCSE attainment? **2)** Are students using the tool more likely to be already motivated, have better access to the service during out of school hours, have higher prior attainment and/or come from a more advantaged background than those not using SAM Learning? **3)** After accounting for the above differences, do pupils using the tool make more progress between KS3 and GCSE?
Study methods	Cross-sectional survey (though not explicitly stated). No methodology section.
Sample age and size	Data was collected on 11,689 Year 11 GCSE students attending around 50 schools in four LAs. NB: More than half of the sample (6,147: 53%) were classified as 'SAM users' and remainder were classified as 'not-SAM users'. No information on how sampling was done.
Includes a control or comparison group?	Yes: between 'SAM users' and 'non-SAM users'. SAM Learning is an online subscription revision service for GCSE and SATs in English secondary schools and is used by more than half of English state secondary schools.
Measures	Information provided by SAM Learning and by the LAs was combined at pupil level with the GCSE results and the Key Stage 2 and 3 results of the pupils as provided by the LAs. Measures were: **1)** Frequency and amount of usage of the e-learning tool **2)** Child characteristics: gender and ethnicity **3)** Socio-economic status: free school meals
Types of analysis conducted	Comparisons by gender and free school meals. Largely descriptive analyses (with no statistical tests reported) and a linear regression analysis performed in order to control for prior attainment in order to explore the effects of the tool on pupil progress between KS3 and GCSE. Although some variations were noted between schools and between LAs (e.g. around 20% of the secondary schools with pupils who did not use e-learning had the same (or similar) levels of prior attainment as those who were using the tool), analyses performed did not control for between-school or between-LA variations. Neither did the analyses control for any other interventions the pupils may have been receiving at the same time.

Study reference	Thomson and De Bortoli (2007)
Study focus	To examine the results for Australia, and in particular: **1)** how extensive access to ICT is in schools, homes and other places **2)** how familiar students nearing the end of compulsory education are with ICT **3)** how well students feel they use the technologies that are available, and **4)** aspects of the so-called digital divide through examining access and use of ICT in Australia by different variables, including socio-economic background.
Study methods	Cross-sectional survey – reports on 2003 results. PISA collects reliable information on a regular basis (every three years) and derives educational indicators that can monitor differences and similarities over time.
Sample age and size	National random sample of 15-year-olds. In 2003 in Australia 12,500 students from 321 schools nationally participated in PISA. The sample ensured the smaller states and indigenous students were adequately represented.
Includes a control or comparison group?	Yes: some international comparisons
Measures	Measures include: **a)** mathematics attainment **b)** 'State1' (State school is in) **c)** pupil gender **d)** indigenous background of pupils **e)** socio-economic background **f)** geographic location. A five-level described performance scale was created (Masters, Adams and Wilson, 1999), which classifies student performance of different countries and thus provides a frame of reference for international comparisons. Further documentation: *PISA 2003 technical report: Facing the future: a focus on mathematical literacy among Australian 15-year-old students in PISA 2003.*
Types of analysis conducted	Descriptive analyses – some correlations with statistical 'significance' reported (but no significance values provided). Analyses were carried out to compare how well students performed in mathematics (the main area of student performance in PISA 2003) by socio-demographic and location characteristics. Possible biases: **a)** self-reported data **b)** possibility of cultural bias in the manner in which questions are answered.

Study reference	Fairlie (2003)
Study focus	US study. Research aims to estimate the causal relationship between home computers and an important educational outcome; in particular, whether access to home computers increases the likelihood of school enrolment among teenagers who have not graduated from high school.
Study methods	Secondary analysis of the cross-sectional survey: *Computer and internet usage supplement to the September 2001 Current Population Survey (CPS)*.
Sample age and size	The survey is representative of the entire US population and interviews approximately 50,000 households. Surveys young people aged 16–18 who have not graduated from high school and live with at least one parent. Parents living in the same household as the young person are identified by using parent and spouse identification numbers provided by the CPS (but cannot distinguish between biological parents and step-parents).
Includes a control or comparison group?	No
Measures	Educational outcome (as measured by school enrolment), controlling for family income, parental education and parental occupations. Also included in the modelling is whether parents have access to computers at work, and their use of the internet.
Types of analysis conducted	Descriptive analyses (without significance testing) and bivariate probit modelling to simultaneously estimate the probability of school enrolment and the probability of having a home computer. Data issues: the author expresses concern about the interdependence of the instruments, and in particular, between parental access to computers at work and their use of the internet. However, he concludes this is not a great concern since analyses (not reported in the paper) show those two variables do not contribute much to the models (they do not have a large effect on the probability of enrolment). He also carries out analyses to 'investigate the sensitivity of the results to several alternative samples' (p. 16). All tests proved the variables of concern were robust, with the possible exception of 'school enrolment' which was slightly sensitive to 'age cut-off' for compulsory schooling which can vary across states.

Study reference	Schmitt and Wadsworth (2004)
Study focus	Explores the link between ownership of a home computer and subsequent educational attainment in the principal British school examinations taken at ages 16 (GCSEs) and 18 (A Levels).
Study methods	Secondary analysis of panel survey: British Household Panel Survey, between 1991 and 2001.
Sample age and size	Longitudinal survey of occupants living in a sample of some 5,000 randomly selected, nationally representative British households. There are around 150 individuals who turn 16 in each wave of the survey. All 16- and 18-year-olds were pooled across the last 10 waves of the survey (1991–2001) to create the sample data sets used in this analysis. This creates a total sample size of 1,450 observations with a full set of control variables on 16-year-olds and 1,500 complete observations on 18-year-olds (p. 6). 16- and 18-year-olds in the first wave were omitted (there is no data for these individuals on their circumstances one year earlier).
Includes a control or comparison group?	No
Measures	GCSE and A Level passes – six educational outcomes: **1)** successful completion of any GCSE at grade C or higher **2)** the total number of GCSE passes **3)** successful completion of five or more GCSEs at grade C or higher **4)** successful completion of one or more A Levels **5)** the number of A Levels and **6)** successful completion of three or more A Levels. Home computer ownership (at each wave). Frequency of home computer use (from wave 4) from which five dummy variables were computed (for 16-year-olds): **a)** made no use of a PC in a household that had one **b)** used a PC 1–2 days a week **c)** 3-4 days a week **d)** most days, or **e)** did not have a computer at age 15. Also control variables (as measured in the year before the relevant examination took place): local area circumstances, household and parental background, as well as the characteristics of the 16- and 18-year-olds in the sample.
Types of analysis conducted	Regression analyses (probit equations) with coefficient estimates provided.

Study reference	Judge et al. (2006)
Study focus	Does technology access differ for children attending high-poverty and low-poverty schools?
	Does computer use differ for children attending high-poverty and low-poverty schools?
	Are there differences in frequency of computer use according to academic achievement and school-poverty concentrations?
Study methods	Cross-sectional, drawn from data collected in a longitudinal study (1998–2004).
	The achievement tests were administered in the spring of 3rd grade.
Sample age and size	8,283 children.
	Sample drawn from the Early Childhood Longitudinal Study, but data for this study was collected at one time point.
	The sample consisted of children in their 4th year of school, 90% in 3rd grade, 9% in 2nd grade and the rest in other grades (1st or 4th grades). This is equivalent to ages 6–10.
Includes a control or comparison group?	A non-equivalent control group: children were stratified according to their schools; schools were classified according to their concentration of children from low-income families, based on the percentage of pupils eligible for free or reduced-price lunches.
Measures	Data were collected from adaptive, individually administered child assessments, parent interviews, and teacher and school administrator questionnaires.
Types of analysis conducted	Descriptive statistics and mean comparisons.
	Used a repeated-measures analysis of variance (ANOVA) to test school poverty concentration differences on access to home computers from kindergarten to 3rd grade.
	Correlational analyses examined relationships between computer resources and use, academic achievement and school poverty status.
	One-way ANOVAs with achievement-group status in relation to school-poverty concentration and frequency of computer use to learn reading and maths.

Study reference	Vigdor and Ladd (2010)
Study focus	Does differential access to computer technology at home compound the educational disparities between rich and poor?
	Would a programme of government provision of computers to early secondary school students reduce these disparities?
Study methods	Longitudinal: administrative data between 2000 and 2005
Sample age and size	Over half a million observations: 747,000 observations were included in most analysis on average – slightly fewer for table 3 (732,000-745,000) which excluded students who were 'missing' data for one or more of the data time points. Students were in grades 5–8 (ages 10–14).
Includes a control or comparison group?	Comparison of student test scores before and after they reported gaining access to a computer.
Measures	Home computer access: brief questionnaire asking students about their computer use at home for school work.
	Achievement tests: not clearly stated but appeared to be end-of-grade tests in maths and reading.
Types of analysis conducted	Main focus on changes in computer access within students across the years.
	Econometric modelling. Tests conducted for heterogeneity on analysis over time.

Study reference	Beltran et al. (2008)
Study focus	Exploration of the relationship between home computer and high school graduation, grades, school suspension and criminal activities.
Study methods	Surveys: 2000–03 CPS Computer and Internet Use Supplements (CIUS) matched to the CPS Basic Monthly Files and the National Longitudinal Survey of Youth 1997 (NLSY97).
Sample age and size	The NLSY97 is a nationally representative sample of 8,984 young men and women aged 12–16 on 31 December 1996, interviewed annually from 1997 to 2002. Various sample sizes are quoted in the analysis tables and it is very difficult to ascertain what they all refer to. The focus of this study was 16–18-year-olds.
Includes a control or comparison group?	No control or comparison group.
Measures	The CPS contains information on computer and internet use. The NLSY97 contains information on computer ownership, educational outcomes, criminal activities and individual and family characteristics.
Types of analysis conducted	They present a theoretical model of high school graduation. Regression analysis of home computer access and high school graduation, controlled for parental education, family income (and other characteristics). Bivariate probit estimates (CPS). Linear regression to consider home ownership and grade point averages (GPA).

Study reference	Borzekowski and Robinson (2005)
Study focus	To examine relationships among a child's household media environment, media use, and academic achievement.
Study methods	During one academic year data was collected in classroom surveys and telephone interviews. Most of the data used was from Spring 2000.
Sample age and size	348 pupils in 3rd grade (out of an original sample of 410) with a mean age of 8.5 years. All of these had mathematics and reading scores, 341 had language arts test scores. 226 parents completed interviews.
Includes a control or comparison group?	No
Measures	Stanford Achievement Test for mathematics, reading and language. Survey of parents and children re. computer access and use at home.
Types of analysis conducted	Linear regression models (adjusting for demographic and media use variables).

Table 5: Critical appraisal and weighting of survey analyses of children/young people, ICT access and academic achievement

Study reference	Study relevance to the review	Are the study methods and results sound?	Overall weight	Include in the review findings?
Fuchs and Woessmann (2004)	3	1	2	**Yes**
Notten and Kraaykamp (2009)	3	1	2	**Yes**
Thiessen and Looker (2007)	3	2	4	No
Osborne (2007)	2	3	4	No
Thomson and De Bortoli (2007)	1	3	2	**Yes**
Fairlie (2003)	3	2	4	No
Schmitt and Wadsworth (2004)	3	2	4	No
Judge et al. (2006)	1	1	1	**Yes**
Vigdor and Ladd (2010)	1	3	2	**Yes**
Beltran et al. (2008)	3	2	4	No
Borzekowski and Robinson (2005)	3	2	4	No

Table 6: Study results of the five studies identified in the synthesis of findings

Study reference	Fuchs and Woessmann (2004)
Study focus	To estimate the relationship between students' educational achievement and the availability and use of computers at home and at school.
Study results	Bivariate correlations that show a positive relationship, once family background and school characteristics are extensively controlled for. For example: 'Holding all other influences constant, the performance of students with internet access at home is statistically significantly better in math and reading than the performance of students without internet access at home' (p. 15). 'Students who never or hardly ever read emails and webpages perform statistically significantly worse than students who use them between a few times a year and several times a month, and students who use emails and webpages several times a week perform statistically significantly better' (p. 15). 'Students that have educational software at home perform statistically significantly better in math' (p. 15). 'Having educational software at home is not statistically significantly related to student performance in reading literacy' (p. 15). The authors suggest some possible interpretations for the positive results: a) The findings reflect that more able students tend to be more likely to have internet access and educational software at home, and particularly that educational software may be being bought by parents for 'low-ability rather than high-ability students' b) 'if ability biases do not account for all of the observed performance differences by computer use, the results may suggest that using computers for productive purposes at home indeed furthers students' educational performance' (p. 15). Despite the extensive use of control variables, the analysis has still been descriptive rather than causal.

Study reference	Notten and Kraaykamp (2009)
Study focus	**1)** To what extent can parental media resources explain differences in children's science performance? **2)** To what extent does a country's level of development affect the relation between parental media resources and children's science performance?
Study results	Baseline model shows: 'children's science performance varies significantly among countries' so that '26% of the variance in science performance of children (15-year-old students) is due to differentiation between countries' (p. 375). Model 1 (adding child characteristics and socio-economic background): **1)** 'Age has a significant positive impact on science performance (b = 15.43), with older students performing better' (p. 375). **2)** 'Children whose parents have a higher educational level (b = 3.54) and occupational status (b ¼ 1.32) perform better in science-related domains' (p. 375). **3)** 'The effect of parental occupational status (1.32*17.03) is larger than that of parental educational level (3.54*3.40): may be due to 'more dominant effect of parental occupational status for children's educational performance in less modern countries'. Model 2 (adding in parental media resources): **1)** 'a more positive parental attitude towards literature and reading, represented by an increasing number of books in the family home, is associated with better performance of their children in science (b = 16.63)'. **2)** 'television access in the parental home is more beneficial for a child's science performance than having no television at all (b = 19.90)' (p. 375). **3)** 'in households with more than one television set, children perform less well in science-related domains' (p. 375). **4)** 'Children growing up in a household with computer access have a head start in school compared to their peers growing up in homes without computer access (b = 18.73)'... and 'every extra computer in the parental home increases a child's science score (b = 7.59)' (p. 375). **5)** Parental resources mediate the effect of socio-economic background on child's science performance: 'including parental media resources in our model explains about half of the effect of parental socioeconomic background. The effect of parental educational level decreases from 3.54 in Model 1 to 1.54 in Model 2, the effect of parental occupational status declines from 1.32 to 0.88' (p. 378). Country-level effects: 'children in more economically developed countries perform better in science than their peers in less developed nations' (p. 378)... and 'various aspects of a nation's development are highly correlated' so that 'including country characteristics reduces the country-level variance by almost 50%' (p. 378). Key conclusions (p. 379–380) are: **1)** 'parental investment in home computers seems to pay off in terms of more successful school performance of children'. **2)** 'The beneficial effect of home computer access on children's school performance remains stable, regardless of a country's level of development'... (and)... 'both parental reading and television socialisation are becoming more important factors in the process of cultural reproduction and social exclusion in modern societies'.

Study reference	Thomson and De Bortoli (2007)
Study focus	The overall aim of the Programme for International Student Assessment (PISA) is to measure how well 15-year-olds approaching the end of their compulsory schooling are prepared for meeting the challenges they will face in their lives beyond school. PISA is administered through an international consortium, led by the Australian Council for Educational Research (ACER). The report examines the results for Australia. In particular: **1)** how extensive access to ICT is in schools, homes and other places **2)** how familiar students nearing the end of compulsory education are with ICT **3)** how well students feel they use the technologies that are available, and **4)** aspects of the so-called digital divide through examining access and use of ICT in Australia by different variables, including socio-economic background.
Study results	Some key findings were: **1)** No gender differences were observed in the length of time students have been using computers (across and within states). However, there were differences by indigenous background: 'compared to 70 per cent of non-indigenous students, only approximately half of the indigenous students have been using computers for more than five years' (and more indigenous females reported using computers) (p. 9). **2)** Indigenous students report using educational software at home to a greater extent than non-indigenous students. For example, 23% of 'frequent using' (defined as 'Almost every day' or 'A few times each week') indigenous students reported using educational software such as mathematics programs, compared with 10% of non-indigenous students (Table 3.8, p. 31); and **3)** 'Evidence shows that the minority of students who still lack access to computers are more likely to underperform at school. The data also shows that these students are not randomly scattered within the population, but are more likely to belong to particular subgroups of the population. This raises equity issues that need to be addressed' (p. 14). **4)** 'After accounting for socio-economic background, the performance advantage of having a computer at home remains significant in four of the eight states. In the Australian Capital Territory, Victoria, South Australia and Tasmania, the performance advantage of having a computer at home is not significant' (p. 14). Socio-economic background had the least effect on performance in the Northern Territory and most effect in Tasmania: the two states with the highest proportion of students without computers at home (7%, p. 14). The authors suggest that a possible explanation for these differences between states may lie in the ways that schools promote computer use in school to compensate for the lack of access at home. However, they are unable to confirm this from the PISA data and suggest this needs further investigation.

Study reference	Judge et al. (2006)
Study focus	Does technology access differ for children attending high-poverty and low-poverty schools?
	Does computer use differ for children attending high-poverty and low-poverty schools?
	Are there differences in frequency of computer use according to academic achievement and school-poverty concentrations?
Study results	Overall, there was a positive correlation between home computer use and achievement in mathematics and reading. However, in high-poverty schools there were significant group differences when students used computers to learn reading: $F_{(2, 1802)}$ – 6.15, $p<0.1$. This indicates that low achievers in reading at high-poverty schools used computers to learn reading significantly more than did high-achieving peers. A similar pattern was found in low-poverty schools.

Study reference	Vigdor and Ladd (2010)
Study focus	Does differential access to computer technology at home compound the educational disparities between rich and poor?
	Would a programme of government provision of computers to early secondary school students reduce these disparities?
Study results	Across-student models indicate that students with access to home computers tend to score about 2% of a standard deviation higher on reading and maths test scores, conditional on a range of covariates (moderate use scored higher than low, no or high use). Students who obtained access to a home computer between 5th and 8th grade tended to score between 1% and 1.3% of a standard deviation lower on their subsequent maths and reading tests.
	The authors conclude that the 'broader expansion of high-speed internet service has no association with test scores among students not participating in the subsidised lunch program' (p. 25). Furthermore, high-speed internet appear to be related to a 'reduction of nearly 3% of a standard deviation in the scores of program participants' (p. 25), and this effect was 'more negative among free and reduced-lunch participants' (p. 25).

Table 7: Study characteristics of identified evaluations

Study	Finn, Kerman, and LeCornec (2005) US study
Sample size/ follow-up	**Intervention:** 34 foster families which included 53 foster parents, 46 foster youth, and 7 foster youth who had transitioned to college. **Intervention follow-up:** 45 parents (84.9%) and 41 youth (89.1%). **Comparison:** 31 foster families. **Comparison follow-up:** 22 families completed the survey by phone (73.3%).
Population, intervention, comparison and outcomes (PICO)	**Population:** Children and young people in foster care aged 7 and above. **Intervention:** Building Skills Building Futures (BSBF) which provided home computers, internet connection and supportive services to eligible Casey Family Services foster families. **Comparison:** Casey Family Services foster families who were not in the BSBF. All comparison families fostered school-aged children. **Outcomes:** Perceptions of attainment and homework.
Length to follow-up	At end of the one-year intervention period (pre-test in autumn 2001 and post-test in autumn 2002).
Study results	Paired sample t-tests found significant differences in mean frequency of use of computers for homework, with a mean increase from 2.49 (SD=1.34) to 3.11 (SD=1.39) ($t=-5.99$, df=34, $p<.014$, ES=4.6). Children's perceptions of programme usefulness for homework: at post-test: 36.6% did not find the programme at all useful or not useful at improving homework, whereas 41.4% found it useful or very useful (M=3.15, SD=1.46). Approximately 70% of parents found the programme to be at least somewhat useful or more in improving homework, and 77.3% found it at least somewhat useful or more for improving grades.

Study	Harris (2010) US study
Sample size/ follow-up	**Intervention:** 30 students **Comparison:** 130 students Retrospective study design.
Population, intervention, comparison and outcomes (PICO)	**Population:** Students eligible for free or reduced-price school lunches. Ages not stated but grades 10–12, indicating that the students were aged 15–18. **Intervention:** All-school provision of free laptops and laptops used in all teaching. **Comparison:** High SES students also receiving free laptops. **Outcomes:** The questionnaire asked students to disagree/agree (five degrees) on the statement 'I am a better student because of my school's use of computers and the internet'.
Length to follow-up	Retrospective study.
Study results	The low SES students believed strongly that their grades had improved due to the laptops. However, teachers did not perceive that laptops affected the achievement gap or improve the academic performance of low SES students compared with their higher SES peers. The laptop provision did not appear to reduce the digital divide between low and high SES students, with high SES students having more computers, higher frequency of access to computers and higher quality computers at school. Teachers perceived laptops as making a positive contribution to learning and teaching, although it was recognised that only teachers interested in using laptops would use them successfully.

Study	Jackson (2006) US study
Sample size/ follow-up	**Intervention:** 140 school students **Intervention follow-up:** N varied from 70 to 108 **Comparison:** None
Population, intervention, comparison and outcomes (PICO)	**Population:** Mostly African American (83%), mostly boys (58%), most living in single-parent households (75%) in which the median annual income was $15,000 or less, eligible for subsidised lunch, never before had internet access. Their average age was 13.8 years (range 10–18), their median age was 13 years. **Intervention:** Free computers, internet access and in-home technical support were provided during the research period (16 months). At the end of the project participants were able to keep their computers and were provided with assistance in finding an inexpensive internet service. **Comparison:** No **Outcomes:** Grade Point Averages (GPAs) and scores on the Michigan Educational Assessment program (MEAP) tests of reading and maths.
Length to follow-up	Ongoing during the 16-month evaluation and at end.
Study results	Descriptive analysis did not show any large differences in GPA across the time period. When controlling for race, internet use did not predict GPA obtained after the first six months of the intervention, but did after one year of home internet access. Internet use during the first six months of the project predicted reading comprehension and total reading scores obtained at the end of that time period ($F[3, 86]$ = 2.59, 283 respectively, $ps<.05$). More time online was associated with higher reading comprehension and total reading scores. Internet use during the last semester of the research predicted reading comprehension and total reading scores at the end of that semester ($F[3, 58]$ = 2.86, 2.96 respectively, $ps<.05$). Mathematics scores could not be predicted from internet use, regardless of the time period and measure of internet use.

Study	**Mouza (2008)** US study
Sample size/ follow-up	**Intervention:** 50 students: 22 in 3rd grade and 28 in 4th grade. I**ntervention follow-up:** 50 **Comparison:** For each laptop class, one comparison non-laptop class was selected. Numbers for these classes are not given, although for the questionnaire they state that 50 completed it at the end of the study (April – May 2003).
Population, intervention, comparison and outcomes (PICO)	**Population:** Students in a school where 94% were Hispanics eligible for free school meals. The students in the study all exceeded or met grade level learning standards in language arts and mathematics. **Intervention:** 'Microsoft Anytime, Anywhere Learning' enabled parents to lease notebooks from Toshiba resellers. Hardware and software were discounted, as were service and insurance contracts. Students had to pay $100 in insurance costs. In the school, laptops were not networked or connected to printers. Internet access and printing facilities were provided by two stationary computers in the classrooms. **Comparison:** Students from the same grades as the intervention sample matched on achievement. These received standard teaching (no use of laptops). **Outcomes:** Attitudes towards school, computer importance and study habits collected on the Young Children's Computer Inventory (YCCI).
Length to follow-up	At end of the one-year intervention period.
Study results	No statistically significant effects found, apart from: Fourth graders who had laptops (M=2.00) had significantly more positive attitudes toward school than fourth graders who did not (M=1.68). Focus group and teacher interviews indicated that laptop students became more motivated to complete school work and often went beyond required assignments. The qualitative data indicated academic gains (writing and mathematics).

Study	Fairlie and Robinson (2011) US study
Sample size/ follow-up	**Intervention:** 559 students who did not have a home computer. **Intervention follow-up:** Survey response rate of 78.7%. **Comparison:** 564 students who did not have a home computer. **Comparison follow-up:** Survey response rate of 76.1%. The authors claim that the reliance on administrative data eliminates concerns over attrition in terms of test outcomes. Follow-up N for these not stated.
Population, intervention, comparison and outcomes (PICO)	**Population:** The sample had a high concentration of minority, immigrant and non-English speaking students. The average education level of the highest-educated parent was roughly 13 years of schooling. The students were recruited from middle and high schools, the average age was 13, and the sample spread across grades 6 to 10. **Intervention:** Free computers were provided with basic Microsoft software. Students could obtain further software and internet provision at their own expense and initiative, and no technical support was provided. **Comparison:** Waiting-list control. **Outcomes:** Grade Point Averages (GPAs) and Standardised Testing and Reporting (STAR) test score results collected each spring for all Californian students. Survey questionnaire about homework and attitude to school.
Length to follow-up	Ongoing and at end of the school year (one academic year).
Study results	GPAs in quarters 3 and 4 of the academic year showed no effect with SE from intent-to-treat analysis just 0.04 in both quarters. This was the same for 'academic subjects' (maths, English, social studies and science). Measured as course success for each class (whether the student passed the class, receiving a D grade or higher) – found a negative and significant, but small, coefficient for English. Measured as course success for each class (whether the student passed the class, receiving a D grade or higher) – found a positive and significant, but small, coefficient for maths. No impact was found on whether students handed in their homework on time, nor on the time spent on school essays or projects. Having a home computer did not alter students' plans on whether to attend college or not. However, the authors note that the college decision was still a way ahead for the students participating in the study. The increase in computer use in the intervention group for homework of 0.8 hours per week is notably lower than the increase in computer use for games and social networking of 1.4 hours. The researchers found evidence that provision of free computers does not have an impact on grades for the average student. Surprisingly the study also did not find an improvement in self-perceived computer skills amongst the intervention students.

Study	Sharp (2003) UK study
Sample size/ follow-up	**Intervention and follow-up:** The evaluation received information on 1,149 pupils who had attended 'Playing for Success' during the evaluation period. Of these, pre- and post-test data on literacy and numeracy was available for 306 pupils in Key Stages 2 and 3. **Comparison:** Pre- and post-data on literacy and numeracy tests for 349 pupils from a previous evaluation of Playing for Success.
Population, intervention, comparison and outcomes (PICO)	**Population:** Underperforming pupils in Key Stages 2 and 3, covering Years 5–9 in school, which corresponds to ages 9–14. Of the students in the evaluation, 16% were confirmed as eligible for free school meals, and 37% were confirmed as not eligible; however, data was missing for 47% of the sample. **Intervention:** 'Playing for Success' which set up study support centres in professional football clubs and other sports venues. Centres were managed by experienced teachers. **Comparison:** Pupils who did not attend Playing for Success, but who were in schools that were sending pupils to the centre. **Outcomes:** Scores on literacy and numeracy tests.
Length to follow-up	One year after the intervention had started.
Study results	Reading comprehension (N=306): Pre-course mean: 86.4 (SD 14.5) – post-course mean: 90.9 (SD 15.6), progress mean 4.5 (SD 15.9) Numeracy (N=266): Pre-course mean: 87.6 (SD 13.1) – post-course mean: 96.3 (SD 13.6), progress mean 8.7 (SD 11.7) Standardised scores on numeracy increased by more than would have been expected over the period. While their pre-scores were 'substantially' below the national norm, their post-scores were 'slightly' below the national norm. In terms of reading comprehension there was a positive change between pre and post test scores, but overall their scores were 'substantially' lower than the national norm both before and after the intervention. Most pupils said they liked the centres and their activities and their ICT skills increased during their time at the centres. The greatest educational significance was evident in pupils' independent study skills and self-image (KS2 pupils only).

Study	SQW et al. (2011) UK study
Sample size/ follow-up	**Intervention and follow-up:** Part of a larger process evaluation. Data on GCSE results for 290 students who were part of the pilot evaluation prior to the national roll-out. **Comparison:** GCSE results for all students in the same area eligible for free school meals, and comparison with all GCSE results in the same area.
Population, intervention, comparison and outcomes (PICO)	**Population:** A large sample of students living in high-poverty areas and eligible for free school meals. Of relevance to this review is data on 290 students in Oldham eligible for free school meals and who took their Key Stage 4 (GCSEs or equivalent) in 2010. **Intervention:** Grants by means of a single pre-loaded card which could be used to purchase a computer with one year's connectivity from approved suppliers. **Comparison:** Students in Oldham who did NOT participate in the 2009 pilot for the Home Access programme and took their Key Stage 4 (GCSEs or equivalent) in 2010. **Outcomes:** GCSE results from the National Pupils Database (NPD).
Length to follow-up	The evaluation was in two phases: January – December 2009 and September 2010 – March 2011. This is for NPD outcomes which were only measured in Oldham where the pilot was implemented in 2009, and GCSE results are for 2010.
Study results	The Home Access uptake students (N=290) were compared with all students eligible for free-school meals (N=641) and all Oldham students at the same grade (N=3,246). The mean for Home Access students was slightly negative. The median average differences indicated that the means were distorted by particularly low -performing tails for all three groups. Both the free school meal group as a whole and the Home Access group improved according to expectations (when considering the median average). However, the bottom 20%, whose performance deteriorated most since predicted grades, underperformed very markedly compared with the bottom fifth of the overall Oldham distribution.

Study	Tsikalas (2007) US study
Sample size/ follow-up	**Intervention:** 174 students in 6th and 7th grade, aged 11–13. **Intervention follow-up:** Pre- and post- N not clear. **Comparison:** No comparison group.
Population, intervention, comparison and outcomes (PICO)	**Population:** 89% of the sample was eligible for free or reduced-price lunches. **Intervention:** Students received a high-quality, refurbished laptop, educational software in math, science, social studies, reading and writing, StarOffice (similar to Microsoft Office), internet access at a reduced rate (8 hours free, then \$9,85 per month). Students were required to attend a family learning workshop with at least one adult from their family. The workshop showed them how to set up the computer and use the software. **Comparison:** No comparison intervention. **Outcomes:** Overall attainment was measured as 'Students' perceived computer impact'. In addition, individual-level data on standardised test scores was obtained from the Department of Education in New York City in the year prior to and the year following the intervention.
Length to follow-up	Survey – six months after provision of laptops. Standardised test scores one year following the intervention, however, the results were discarded because the tests had been changed from previous years. Instead, they used the previous years' test scores as covariates in relevant statistical analyses.
Study results	The paper says that 'prior reading levels were positively and significantly associated with use of computers for SRL' but it is difficult to ascertain what is meant by this – although it does indicate they are talking about reading skills before the intervention (does not make much sense without stating post-intervention levels). The study claim to have found a significant and positive relationship between home computing factors, students' engagement and students' math test scores. The authors say that students' maths test scores correlated, in the following order with the following variables: previous year's scores, frequency of home internet use, engagement with school and use of computers for self-regulated learning. 54% of students said they used the computer 'often' or 'very often' for homework help and 36% said they used it for practising or improving their maths skills.

Table 8: Weighting of evaluation quality and relevance

Title	Methods	Appropriateness of methods	Relevance	Overall weight
Fairlie and Robinson (2011)	High	High	Medium	High/Medium
Finn et al. (2005)	Low	Medium	Medium	Medium/Low
Jackson et al. (2006)	Medium	Low	High	Medium/Low
Harris (2010)	Low	Low	Medium	Low/Medium
Sharp et al. (2003)	Low	Medium	Low	Low/Medium
SQW et al. (2011)	Low	Low	High	Low/Medium
Tsikalas et al. (2007)	Low	Low	High	Low/Medium
Mouza (2008)	Low	Low	Low	Low

In Table 8, studies are ranked so that the study with the highest overall score is listed at the top (Fairlie and Robinson, 2011) and the study of lowest relevance and quality is listed at the bottom. Those who achieved the same score are listed in alphabetical order.

Table 9: Quality of studies which tested for changes in academic performance

Title	Methods	Appropriateness of methods	Relevance	Overall weight
Fairlie and Robinson (2011)	High	High	Medium	High/Medium
Jackson et al. (2006)	Medium	Low	High	Medium/Low
Sharp et al. (2003)	Low	Medium	Low	Low/Medium
SQW et al. (2011)	Low	Low	High	Low/Medium
Tsikalas et al. (2007)	Low	Low	High	Low/Medium