EVALUATING TECHNOLOGY-RICH ICT INITIATIVES IN SCHOOLS: WHAT DOES THE LITERATURE TELL US?

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INTRODUCTION

This paper summarises the information gained from a review of the literature surrounding the evaluation of technology-rich initiatives in the compulsory schools sector in New Zealand and overseas (Boyd 2001). The literature review was commissioned by the Ministry of Education. The purpose of the review was to provide information about the evaluation of information and communication technologies (ICT) initiatives, and summarise the findings of these initiatives, in order to inform the evaluations of the four Digital Opportunities projects currently underway in a number of New Zealand schools. Accordingly, evaluations and research involving four main types of school-based ICT initiatives were focused on in the review:

- Laptop school projects.
- Homework or study centres.
- Projects which involve the use of the Internet to deliver resources (including online distance learning projects).
- Vocational education initiatives which give high school students the opportunity to gain recognised ICT qualifications.

This paper is in three sections; the first provides background on the literature review and the Digital Opportunities projects in New Zealand; the second provides an overview of the evaluations of two of the areas, that is, laptop schools and study centres; and the third presents some of the conclusions from the review.

Background

The review concerned evaluations of projects that are considered relevant, but not necessarily limited to, the ICT delivery methods that are being implemented as part of the four Digital Opportunities projects and focused on international and New Zealand literature from 1990. The projects reviewed attempted to lessen the digital divide, that is, they provided students (and in some cases families and communities) of low socio-economic status or in rural or isolated areas with increased access to technology. In particular, evaluations of ICT initiatives that included empirical evidence about the effects of the processes and outcomes of these initiatives were examined.

Only a small number of evaluations of "laptop school" projects aiming to bridge the digital divide were located. Laptop schools historically have been located in high-income communities due to the amount of funding necessary to provide such initiatives. Therefore, for laptop projects, the scope of the review was broadened to include all laptop school evaluations.

The majority of evaluations located for the review were situated in the U.S. and Australia. For this reason a decision was made to focus on the main school-based initiatives and projects, and their associated evaluations, in New Zealand, Australia, the U.S., the U.K. and Canada.

The review aimed to comment on the main studies that are similar to each Digital Opportunities project but did not necessarily cover the whole range of literature for each of the four areas.

The four Digital Opportunities projects in New Zealand

The Ministry of Education has initiated four digital opportunities projects (MoE 2001a). The general aim of these projects is to assist in bridging the digital divide for low decile schools or schools for which access to adequate ICT infrastructure has previously been limited. The projects are developed from a partnership between schools, businesses, and Government. The general goals of the projects are to:

1. Enhance the educational achievement of the students and community particularly in mathematics and science.
2. Help overcome the barriers of access, ability, and attitude.
3. Work in partnership with all stakeholders.

(p.8, Digital Opportunities contract, project 4, MoE, 2001b)

The implementation of the four projects was started in 2001. Each project will run for the 2002 and 2003 school years. The four projects are:

- **Laptops for teachers and senior students in the Hutt Valley, Wellington (Notebook Valley)**

  Notebook Valley is a laptop school project in which students and teachers at three schools in the Hutt Valley and Wainuiomata are provided with personal laptops, training, and access to the Internet both at school and at home. This project aims to improve student achievement by providing access to tools and resources for learning, and increase retention in senior science and mathematics.

- **ICT-boosted study support centres in Southland and Canterbury (WickED)**

  WickED provides three study support centres, accessible to year 5 to 8 students and the community, in Southland and Canterbury, with computers, software, and professional development, high quality connections to the Internet, and technical and student support. This project aims to enhance student learning outcomes through the use of ICT-based resources and develop local "learning communities".

- **Learning communities in the far North (FarNet)**

  FarNet provides 10 schools in the Far North with access to: computers, software, and professional development as well as high quality connections to the Internet. Through access to Te Kete Ipurangi – The Online Learning Centre (TKI) teachers and students are provided with bilingual learning resources and the opportunity to create resources using existing materials from Television NZ and Independent Newspapers Limited archives. The resources are designed to make mathematics and science more relevant to students, and therefore improve student retention in these subject areas.

- **ICT technology training in West Auckland and Gisborne (GenXP)**
  GenXP is a vocational education project that provides students in five low decile secondary schools in West Auckland and Gisborne with access to computers, software, and professional development as well as high quality connections to the Internet. Students are provided with the opportunity to gain, as part of the NZQA framework, vendor technology qualifications from Microsoft and other providers. Gaining these qualifications will hopefully assist students to gain entry to the workforce.

EVALUATION DESIGNS

The evaluations reviewed were classified using three categories: formative, process, or outcome. Most of the evaluations did not include a discussion of the model of evaluation used but many commented on whether one or more of these three approaches was taken.

Evaluating laptop school projects similar to Notebook Valley

Laptop schools internationally

There are many "laptop schools" around the world. Australia has been pioneering in its utilisation of laptops in schools. A school-wide reform approach, the School Design Model (SDM), which was developed in Australia, has been adapted for use in the U.S. (Bain 1996) and is the foundation for the Microsoft Anytime, Anywhere Learning (AAL) programmes in the U.S., the U.K., Australia, and Canada. A couple of independent longitudinal multi-site evaluations of the AAL have been undertaken in the U.S. (Rockman *et al.* 2000) and the U.K. (Passey *et al.* 1999 & 2001).

New Zealand has a number of primary and secondary schools in which students use personal laptops. Evaluations of some of these programmes are available, for example, the King's College Computer Project (Parr 1992; Parr 1993); and the St Cuthbert's Junior School College laptop project (Selby, Elgar, & Ryba 2001).

Extending the laptop school concept to low-income schools is a relatively new idea. Only one evaluation reported on was conducted solely in a low-income community (Ricci 1999), two others reported findings for low-income students (Stevenson 1999; NetSchools Corporation 2001). A number of other evaluations include low-income schools, but findings for these schools are not reported separately (Passey *et al.* 1999; Rockman *et al.* 2000; Stradling *et al.* 1994; Shears 1995).

Focus and nature of the evaluations

The majority of the evaluations and research concerning laptop schools in the review were financed by the programme funders and conducted by independent researchers and evaluators.

Most of the evaluations were oriented towards reporting on outcomes, although many also contained formative and processes approaches. Only a minority of reports included any discussion of how the evaluation fitted into either a model of evaluation or a model of school change (e.g., Bain 1996).

Other laptop school initiatives were introduced as part of new teaching and learning models such as the Microsoft AAL approach (e.g., Rockman *et al.* 2000; Passey *et al.* 1999) and other constructivist models. These models were oriented towards the use of new technologies and

how this use could facilitate a change in philosophies concerning teaching and learning, but did not necessarily include a focus on how evaluation fitted into this process.

The formative component of the evaluations concentrated on identifying implementation issues that could be resolved. Most evaluations included some process components, that is, describing and documenting the implementation, but this was not usually included in the goals of the evaluation.

For outcome evaluations the focus was on evaluating the impact or effect of the programme. The focus could be general such as the impact or effect of the programme on teaching and learning (Newhouse 1999), or it could be specific such as the impact or effect of the programme on students' test scores (Rockman *et al.* 2000), students' technology skills (Robertson *et al.* 1997), or other specific skills such as writing (Hill *et al.* 2000).

In a few cases a more conditional approach was taken, for example, the goals of the Passey (1999) evaluation were to identify

- positive practice and outcomes where this occurs, and to consider why, how, and under what conditions this occurs.
- less positive practice and outcomes where this occurs, and to consider similarly why, how, and under what conditions this occurs. (p.9, Passey 1999)

Design of laptop school studies

The majority of laptop school studies examined in the review include a longitudinal multi-method case study of a single site (e.g., Bain 1996), a longitudinal multi-method comparison studies across a number of sites (Rockman *et al.* 2000; Passey *et al.* 1999; Gardner *et al.* 1993; Stevenson 1999), or a multi-method one-year case study of a single site (Robertson *et al.* 1997; Selby, Elgar, & Ryba 2001; Parr 1992; Parr 1993). On the whole the most common design was a case study. As noted by Yin (1994) this type of design is usually employed for phenomena such as innovations (for example, new technology) in school settings.

All studies typically used a mix of quantitative and qualitative methods to collect data from a range of stakeholders: students, teachers, school administrators, and parents. A number of the studies compared student data with other non-laptop groups, mostly at the same school (e.g., Ricci 1999; Parr 1992; Passey *et al.* 2001; Gardner *et al.* 1993; Stevenson 1999) and occasionally at other schools (Newhouse 1999; Bain 1996). One study involved both types of comparison groups (Rockman *et al.* 2000).

The longitudinal case studies and comparison studies that covered two or three years of the implementation of a programme, usually collected some common data each year. Typically an evaluation of the implementation of the project was conducted in the first year, and then an analysis of student outcomes was conducted further into the programme. An element that was rarely included in the longitudinal designs was a follow-up after more than three to five years from the initial implementation. Newhouse (1999) was one exception to this.

Some studies (Stevenson 1999; Newhouse 1999) only showed significant gains in student achievement measures after a minimum of three years into the evaluation. Longitudinal studies over two or three years in length appeared to be better placed to show conclusive changes in terms of student outcomes (Stevenson 1999).

Most projects included the use of interviews with school administrators and teachers to develop a picture of how the project was implemented as well as the successes and challenges of the project. In addition to this information most projects included a consideration of a number of

outcomes. Table 1 summarises a range of typical expected outcomes of laptop school evaluations and some of the common ways these outcomes were measured.

Table 1

Expected Outcomes and Methods of Measurement for Laptop School Projects

Expected outcome	**Common measurement methods**
ICT access and usage	
Increased access to computers for students and teachers, and in some cases the students' family.	Data on access to ICT, student and teacher questionnaire, and teacher interviews. (Parent questionnaire or interview for home data).
Increased use of computers by student and teachers (frequency, in a range of subjects, at home, using a range of applications, types of activities undertaken).	Student and teacher questionnaire and teacher interviews.
Student learning at school	
Increased ICT skill development.	Student questionnaire and pre- and post-test of ICT skills.
Improvements in indicators developed from the goals of the project the most common being: improved presentation of work; improved writing, editing, spelling, and grammar skills; mathematics and science data handling ability.	Specially designed assessments to suit the indicator and analysis of work samples.
Increased or maintained standardised test scores, classroom test scores, external examination scores, and other measures of educational achievement.	Standardised test scores, grades, examination scores, school records, and analysis of work samples.
Increased programme completion and qualifications.	School records.
Increased information literacy skill development, including problem-solving ability, self-directed learning, independent learning.	Student and teacher self-report in interviews, questionnaires, and focus groups. Classroom observations.
Changes in types of classroom activities involving ICT use, e.g., more presentations to class.	Student and teacher self-report in interviews, questionnaires, and focus groups. Classroom observations.
Student learning at home	
Increased completion of homework/less TV watching.	Student and parent questionnaires and interviews.
Increased parental assistance with homework.	Student and parent questionnaires and interviews.
Increased use of ICT at home for learning purposes.	Student and parent questionnaires and interviews.
Attitudes and motivation	
Positive attitudes towards the project and computer use by students, teachers, and parents. For students: improved attitudes towards learning.	Student, teacher, and parent interviews and questionnaires. Attitude scales.
Increased student motivation and interest (e.g., increased homework completion).	Student, teacher, and parent interviews and questionnaires.
Improvements in student self-esteem.	Student and teacher interviews and questionnaires.
Student behaviour	
On-task behaviour.	Classroom observation.
Increased co-operative behaviour/peer tutoring observed.	Classroom observation and student and teacher questionnaires and interviews.
Increased ability to direct own learning.	Classroom observation and students and teacher questionnaires and interviews.
Lower suspension rates.	School data.

Classroom and learning environment	
Integration or "institutionalisation" of ICT across the school and into classroom practice.	Student and teacher interviews and questionnaires. Classroom observations. Scales assessing classroom environment.
Classroom organisation (a wider range of teaching strategies used).	Teacher interviews and questionnaires. Classroom observations.
Nature of tasks (students are given real life tasks that motivate them).	Student and teacher interviews and questionnaires. Classroom observations.
Teacher-student relationships (increased learner-centred/constructivist learning environments).	Teacher interviews and questionnaires. Classroom observations.
School and post-school data	
Improved retention rates (roll increase, larger number of students staying at school).	School data.
Improved attendance rates (absentees and late arrivals).	School data.
Student destinations (such as further study or employment).	Student follow-up questionnaires or interviews or intentions survey.

Findings from the evaluations of laptop schools

Low-income

Very few studies included a consideration of the outcomes for low-income students, but those that did reported positive findings (Ricci 1999; NetSchools Corporation 2001; Stevenson 1999). Ricci (1999) and NetSchools Corporation (2001) reported that the use of technology had assisted in improving the link between school and home. Ricci (1999) and Stevenson (1999) reported that the laptop students in their study maintained their test scores in comparison to non-laptop students whose test scores decrease over time. NetSchools Corporation (2001) reported increases in test scores. NetSchools Corporation (2001) reported declines in student absenteeism, and time-on-task in the classroom, and an increase in school effectiveness. Declines in absenteeism were also reported by Stevenson (1999). The students in Ricci's (1999) study stated that, at home, they spent more time on homework and less time watching TV, and that using a laptop had improved their performance and their attitudes to school. The parents and teachers in this study supported these findings.

All laptop school studies

Most reports included a description of some of the successes and challenges of the project (e.g., Rockman *et al.* 2000; Bain 1996; Owen & Lambert 1996). On the whole most findings were positive (the range of expected outcomes is noted in Table 1), although in a couple of cases little change in practice beyond students using laptops as a word processor were reported (Ainley *et al*. 2000; Newhouse 1999). Universally reported as an outcome were increases in students' and teachers' ICT skills, and access to and usage of ICT at school and at home, as a result of laptop projects.

The often-reported improvements in students' achievement, attitudes, motivation, and information literacy skills were not necessarily clearly reflected in changes to student achievement measures (Rockman *et al.* 2000; Gardner *et al.* 1993). Positive changes to student achievement were more likely to be reported from qualitative, rather than quantitative data. Data concerning students' achievement on standardised tests and external examinations on the whole were inconclusive. Some authors questioned the validity of these tests in measuring the types of gains expected from ICT innovations (Rockman *et al.* 2000; Gardner *et al.* 1993). However, indicators of student achievement that were specifically tailored to the goals of an initiative, such as the ability to handle mathematics and science data, (for example, as developed by Passey *et al.*, 2001) were not necessarily any more successful in quantifying gains. In some cases these measures did show more variation than standardised tests, for example, Rockman *et al.* (2000) reported inconclusive data from comparisons of standardised

test scores, but laptop students' scores on writing assessments were significantly higher than non-laptop students.

Aside from the suggested lack of validity of the quantitative measures used to assess student achievement, there are two possible reasons for the reported lack of impact. One is that the use of laptops does not in fact have any effect on student achievement. The other, perhaps more likely, reason is that changes to student achievement are conditional on context, that is, changes are due to complex interplay of factors such as teachers changing their pedagogical approaches to support a more student-centred environment in which ICT use is integrated into the curriculum and ubiquitous. If this does not occur, and laptops are used within the traditional classroom environment simply as word-processing and presentation devices, then it is unlikely that improvements in student achievement or changes to classroom environments will be evident.

The importance of context can be seen from the results of a number of studies, for example, Passey *et al*. (2001) reported a wider range of significant gains in student spelling, and mathematics and science data handling skills, in the only school out of five that had addressed most of the "key integration factors" identified in their study. Fisher and Stolarchuk (1998) provided evidence that supported higher student engagement and achievement in student-centred self-directed learning environments.

A few studies reported negative outcomes for students, for example, Robertson *et al*. (1997) reported lower achieving students became de-motivated by laptop use. Kessell (2001) reported that the older students in their study (year 5 and 6) did not view the laptop project at their school positively compared with the younger students in the project.

The main challenges of these laptop projects were the increase in teacher workloads and the fact that teachers took time to adjust to the new student-centred environment that ICT use could facilitate and therefore needed more professional development and technical support. The need for more professional development on how to integrate ICT use into the curriculum was suggested by many evaluators (Ricci 1999; Robertson *et al.* 1997; Gardner *et al.* 1993; Kessell 2001; Stevenson 1999; Newhouse 1999).

In summary, as Kessell (2001) noted, one of the most important factors in the success of an initiative is undoubtedly the willingness of teachers to put in the extra work required. Related to this was adequate professional development and technical support and a shared vision for the use of ICT throughout the curriculum.

A future focus for evaluations of laptop school projects could be a closer examination of the conditions within the school and the learning environment that are necessary to produce changes in student outcomes.

Evaluating study centre projects similar to WickED

A paucity of research and evaluation data on technology-rich study centres in low-income communities exists, probably due to the relative newness of this area and the community-based nature of funding for many of these initiatives (resulting in a lack of funding for evaluations). Some descriptive documentation of technology-rich after-school programmes is available but little evaluation information.

An approach to the provision of access to ICT that is similar to the study centres in NZ is the development of the technology-rich community technology centers (CTCs) located in the U.S. and Canada. Both study centres and CTCs provide access to ICT primarily for underserved populations. Study centres are focused on programmes for students but also aim to support the local community, whereas CTCs have a slightly broader focus in that they are located in a

wider range of host organisations; primarily schools, libraries, or community buildings, and offer a range of ICT-related programmes which serve a number of target populations, but usually include the development of programmes for school-aged students and youth as one of their main foci. In New Zealand there are a number of similar community centres such as the Wairoadotcom and Cyber Tek centres described in Barker (2001). A number of evaluations of CTC were discussed in the review, in addition to a consideration of the literature surrounding technology-rich after-school programmes.

Focus and nature of the evaluations

On the whole the evaluations of projects similar to study centres were conducted by commissioned researchers. Due to the unique range of programmes offered by each study centre the research design most often employed in evaluating these programmes was a multi-site, multi-method, case study. About half of the case studies were longitudinal and the others were snap-shots.

The majority of study centre evaluations focus on collecting qualitative implementation data or information that described the nature of the programmes. Outcome data was presented when it was available. A smaller number of evaluations include a focus on assessing the impact of the programme on student outcomes (e.g., Dynarski *et al.* 2001; Michalchik & Penuel 2001; Latino Issues Forum 2001).

Aside from documenting the implementation of the centre, and the nature of the programmes, the primary goal of most of these evaluations was to identify and document good practice so that it could be replicated in other settings (e.g., Penuel *et al.* 2001; Dynarski *et al.* 2001; Penuel & Kim 2000; Henriques & Ba 2000; Breeden *et al.* 1998). In recognition of the difficulties centres faced in documenting outcomes, another main goal of these evaluations was to develop a strategy to assist centres to evaluate their programmes (Raphael & Chaplin 2000; Penuel *et al.* 2001; Michalchik & Penuel 2001; New Economy Development Group Inc. 1998).

Methods and focus of data collection

Outlined below is a summary of the main types of information that were collected about the centres and the ways this information was collected.

- **Descriptive information about the centre, its history, and the implementation of programmes and their outcomes.** This information covered, for example, how the project was implemented, infrastructure, technical support, staffing, funding, outcomes for participants, and successes and challenges. This information was mostly collected from interviews with programme directors and staff (Penuel *et al.* 2001; Macias *et al.* 2000; Dynarski *et al.* 2001; New Economy Development Group Inc. 1998; Raphael & Chaplin 2000; Penuel & Kim 2000; Henriques & Ba 2000; Breeden *et al.* 1998). Observations of programmes in action were also conducted to give evaluators a picture of the programmes provided (Raphael & Chaplin 2000; Penuel & Kim 2000). In some cases interviews were conducted with other stakeholders such as partnership organisations concerning the development, implementation, and continuation of the programme (Penuel *et al.* 2001; Dynarski *et al.* 2001; Macias *et al.* 2000).

- **Data about the range of programmes offered, and the clients served, and levels of attendance.** This information was collected from centre records (Penuel *et al.* 2001; Raphael & Chaplin 2000; Henriques & Ba 2000). Information on this area was also collected from the interviews with centre staff.

- **Impact of the programme on students' behaviour, attendance, and academic achievement at school**. This information was mostly collected from interviews or surveys of participants' school teachers and collection of students' school records or results on standardised tests (Dynarski *et al.* 2001; Latino Issues Forum 2000; Latino Issues Forum 2001).

- **The use of the technology at the centre by participants and the benefits of the centre for participants**. This information was collected from participants via interviews, surveys, or focus groups (Penuel *et al.* 2001; Dynarski *et al.* 2001; Raphael & Chaplin 2000; Penuel & Kim 2000; Latino Issues Forum 2000; Latino Issues Forum 2001).

- **The use family members made of the centre, and outcomes for themselves and their children**. This information was collected from interviews or surveys of parents (Dynarski *et al.* 2001; Latino Issues Forum 2000; Latino Issues Forum 2001).

Findings from evaluations of study centre programmes

Along with documenting and describing the centre programmes, a wide range of positive outcomes from study centres were reported from these evaluations. Perhaps the most common were:

- Increases in participants' access to ICT and development of ICT skills (Penuel *et al.* 2001; Macias *et al.* 2000; Latino Issues Forum 2001; Henriques & Ba 2000).

- Students spending extra time on academic activities or receiving assistance with homework (Penuel *et al.* 2001; Raphael & Chaplin 2000; Henriques & Ba 2000).

The main challenges identified were sustainability and sourcing continuing funding (Penuel *et al.* 2001; Penuel & Kim 2000; Macias *et al.* 2000; New Economy Development Group Inc. 1998; Henriques & Ba 2000) and providing trained staff or staff from the local community (Penuel *et al.* 2001; Penuel & Kim 2000; Macias *et al.* 2000; Henriques & Ba 2000).

A number of authors attempted to identify the conditions necessary for effective and sustainable programmes. The most common factors appeared to be:

- Well-trained staff (Macias *et al.* 2000; Breeden *et al.* 1998; Fashola 1998; Penuel & Kim 2000).
- Strong leadership or a shared vision (Breeden *et al.* 1998; Macias *et al.* 2000).
- The programmes were grounded in the local community (Breeden *et al.* 1998; Penuel & Kim 2000).
- Effective programme planning and design (Macias *et al.* 2000; Breeden *et al.* 1998; Fashola 1998).
- Expert support (Breeden *et al.* 1998; Macias *et al.* 2000).
- An evaluation culture (Breeden *et al.* 1998; Penuel & Kim 2000; Fashola 1998).
- Providing up-to-date technology (Penuel & Kim 2000; Macias *et al.* 2000).
- Skill in acquiring new sources of funding (Penuel & Kim 2000; Macias *et al.* 2000).

A feature that seemed to be crucial to a successful programme (that is it was identified in all of the studies that discussed success factors) was the presence of trained staff or staff from the community served by the centre. A future direction for evaluation of study centre programmes could be a more in-depth examination of student outcomes.

SUMMARY AND CONCLUSIONS

Although the four types of projects in the review were mostly located in technology-rich environments in schools, in some cases this was almost their only connection. Laptop schools and study centres have some elements in common, but ICT certification and vocational education projects are very different in nature to the others. Accordingly, it was difficult to summarise common themes between these four projects. A number of debates and concerns discussed in the literature are mentioned below. In most cases these debates are relevant to laptop schools, resource development, and study centres projects, but are less likely to be relevant to ICT certification and vocational education projects.

Additional goals for projects in low-income communities

ICT projects in low-income schools have a different emphasis from those in high-income schools. Evaluations of laptop projects and study centres conducted in schools that served low-income areas have often focused on collecting data on an additional set of possible outcomes such as:

- improved student attendance,
- improved student retention,
- development of student career goals,
- increased student self-esteem,
- increasing the access of the community to ICT,
- development of family or community ICT skills,
- increased communication between home and school and involvement of parents and the community in the education of their children, and
- decreased incidence of negative behaviours by students such as bullying.

Evaluations of projects in low-income schools often include indicators that aim to measure whether the use of ICT encouraged disenchanted students to stay at school. This appears less of a concern for schools in high-income areas that already have high retention rates and students motivated to continue to tertiary education.

Design of evaluations

Assumptions about technology

Commentators on the digital divide have suggested that too much emphasis has been placed on increasing access to technology rather than focusing on the objectives for using technology. It is likely that this situation has developed from the somewhat potted history of evaluations in the ICT area which, in the past, have suffered from the problem of the technology being seen as an end to itself rather than only one part of the equation. This concern has been reported in Parr (2000) in relation to studies concerning integrated learning systems, and in Culp, Hawkins, and Honey (1999) who suggested that early research and evaluations of ICT initiatives implicitly viewed technology as a "black box". This research assumed that technology was the only variable and looked for evidence of student learning as a result of "applying" this variable (usually measured by test score gains). This type of approach ignored pedagogy, teacher practices, and student experiences. The design of earlier ICT evaluations and research has tended to encompass a number of "black box" assumptions (Gardner *et al.* 1993; Robertson *et al.* 1997). The projects in which technology was viewed as a "black box" tended to lack a clear set of goals for the use of technology other than to increase access.

A lack of clarity concerning programme goals and purposes (Fouts 2000) or learning objectives (Schacter 1999) has been reported in the literature summarising evaluation studies. Another related issue is ensuring that the goals of the evaluation match the goals of the programme (Culp, Hawkins, & Honey 1999).

One enduring problem with the use of ICT in schools, as summarised by Schacter (1999), is that on many occasions programme developers and funders are more concerned about the "hardware" that is, equipment, rather than the "software" such as learning goals and professional development. This situation stems in part from the situation described above, that is, viewing ICT as a "black box". The lack of clear programme goals undoubtedly contributes to some of the variability present in study findings, especially in the case of laptop school studies. In some of the evaluation reports it was unclear what the goals of the programme were. In one case, goals were alluded to but not outlined (Newhouse 1999); in other cases programme goals were not clearly documented in the evaluation or research report, although they may have existed (Gardner *et al*. 1993; Rowe 1993); and in further cases, due to a lack of clear goals, the evaluators recommended that the school develop a set of learning goals for the programme (that is, other than teachers and students using ICT and developing their ICT skills) (Woodbridge 2000; Parr 1993).

These programme that did not have clear goals accepted a **simple level** of programme success. That is, the innovation was viewed as successful if students, parents, and teachers expressed positive attitudes towards the programme, the programme had increased student and teacher ICT access and usage, and had developed the ICT skills of students and teachers (in the case of laptop and study centre projects), or had expanded student access to new subject areas and experiences (in the case of study centre or resource development projects). In these situations general measures of academic achievement (such as standardised tests) were often used to assess changes in learning outcomes. These measures mostly showed variable or no clear improvements in learning outcomes for students. The "how", that is, how the technology was to be integrated into the curriculum, was ignored.

The acceptance of a simple level of success was more common for ICT initiatives in the early 1990s when the main goal of many programmes was to increase the use of technology and therefore the main goal of the evaluation was to report on this increase. This approach was problematic for teachers and evaluators. In schools that adopted this "sole goal" teachers reported that they needed professional development on how to integrate ICT into the classroom in addition to the skills-based training provided. Evaluators suggested that ICT skill development alone is not enough of a reason for a programme. As Venezky and Davis (2001) concluded:

> Successful implementation is not simply a technical issue. It requires a vision about education and about the specific educational goals that ICT is to support. An ICT plan by itself is incomplete. Policy makers should ask first for a strategic schooling plan and then for an ICT plan for supporting educational goals. (p.46, Venezky & Davis 2001)

In time the focus of programmes and evaluations has moved away from the "black box" approach; programme goals have become more complex and evaluations have become more orientated towards addressing the context of the ICT innovation and examining additional student outcomes (e.g., Passey *et al.* 1999; Selby, Elgar, & Ryba 2001).

Evaluations in the late 1990s were more likely to focus on identifying the conditions that were necessary for the innovation to be successful (e.g., Passey 1999). The evaluations of programmes such as these look for more **complex** indicators of programme success. Complex level success factors for laptop schools could be students exhibiting more on-task behaviours, or developing their information literacy or data handling skills further. Other success factors at

the complex level included whole school change in terms of integration of ICT into the curriculum and school administration practices, and changes in the classroom environment towards a learner-centred environment. This is the focus of some of the more recent laptop schools evaluations.

Focusing on the conditions necessary for the successful introduction and continuation of a programme is an approach that is favoured by commentators in this area such as Culp, Hawkins, and Honey (1999). They have suggested that a "consensus has emerged" in regard to the wider issues that need to be addressed when examining ICT initiatives, that is, understanding *how* the innovation occurred and examining the nature of *successful* innovations. The characteristics of research and evaluations that address this issue are that:

- researchers and evaluators have an understanding that the use of technology is not an end in itself and that ICT use needs to be understood in context;
- the goal of the research is to understand how the innovation occurred (not just what the outcomes were or how it assisted students to achieve within the traditional paradigm);
- the research or evaluation is multidisciplinary and involves long term collaboration with educators at different levels of the school system.

Evaluation timeframes

The evaluation literature suggests that conducting an outcome evaluation in the first set-up year while the programme in still in a state of change is problematic. The large international OECD Case Studies of Organisational Change project only selected school that had at least a previous two-year implementation period (OECD 2000). Some recent laptop school evaluations only reported significant changes in student outcome measures after a minimum of three years into the evaluation (Stevenson 1999; Newhouse 1999). As Stevenson noted change in school systems and in students' learning practices can be slow. This situation is also reported in regard to ICT initiatives other than laptop schools. In the evaluation of an online resource development projects, Tyner (2000) reported that it took two years to build the infrastructure before teaching and learning outcomes could be measured. In another project, Jackson and Guerin (1999) noted that it could take teachers three to seven years to become familiar with using technology. This information implies that a one- or two-year timeframe could be too short to adequately do justice to reporting the outcomes of a programme. In recognition of this, many evaluations document the process of implementation in the first year of the evaluation, and the outcomes in the 2nd or 3rd year.

Selecting a comparison group

The use of a comparison group can be a valuable way of ascertaining programme effects and is commonly employed in evaluations of ICT initiatives in schools. This type of design was included in evaluations of the four types of projects in the review. Comparing outcomes between groups of programme and non-programme students or teachers at the same school was a common method of providing data in laptop schools in which laptops have been provided to some classes of students at a school and not others (e.g., Ricci 1999; Parr 1992; Passey *et al.* 2001). In schools in which the programme model was applied to the whole school, comparison groups from other schools were sometimes included in the evaluation design (Bain 1996; Newhouse 1999). Comparison groups were also part of the design of some study centre projects (Dynarski *et al.* 2001; Fashola 1998), and vocational education projects (Polesel, Teese, & O'Brien 1999; Bragg 2001).

There are a couple of drawbacks of using an in-school comparison group. One of these is highlighted by Rockman *et al.* (2000), that is, the characteristics of non-programme and programme students can grow more similar over time. Rockman *et al.* suggested that this could be due to the sharing of pedagogical approaches and ICT skills between the teachers and

students in the two types of classes. Another drawback of using comparison groups suggested by Fashola (1998) is the difficulty of finding matched control group for study centre programmes for which students self-select to participate. This difficulty also applies to vocational programmes such as Tech-Prep, in which students who participate can have different achievement and socio-economic levels (Bragg 2001).

Collecting data only from exemplar sites

Selecting exemplar sites only is a valid research design, but the selection needs to be made transparent to the reader, for example, Penuel and Kim (2000) do this to document some of the more innovative CTC programmes available. The use of non-random or self-selected sampling techniques is a way in which exemplar sites could be unwittingly selected. In the Rockman *et al.* (2000) study of laptop schools, 8 of the 29 pilot sites participated in the evaluation; many sites were excluded for a number of reasons. This could result in findings that are not representative of the group as a whole.

What indicators to use?

Many of the studies in the review relied heavily on stakeholder self-report to indicate the success of the programme and identify outcomes for students. Some caution must be exercised in using attitudes as an indicator unless positive attitudes or attitudinal change can be shown to relate to improved learning outcomes. This is not necessarily the case. Parr (2000) noted that attitude has been shown to have no significant connection to learning outcomes in relation to integrated learning systems (Wood, Underwood, & Avis 1999). For this reason Parr excluded attitude as an indicator of learning outcomes in her review of the outcomes of computer-assisted learning. This debate is relevant to the use of ICT in schools in general. In many of the evaluations reviewed attitudinal data was not corroborated with other data. Positive changes to student achievement were more likely to be evident from self-report qualitative data than quantitative data on the same area (e.g., Rockman *et al.* 2000; Gardner *et al.* 1993).

One of the reasons for this lack of match could be that standardised or other test results are not a valid measure of gains expected from ICT innovations (Spielvogel *et al.* 2001; Rockman *et al.* 2000). Spielvogel *et al.* (2001) commented that only a few items in the test used in their study could be directly related to the goals of the programme and Rockman *et al.* (2000) concluded that there:

> . . . tends to be a disconnection between the purposes of laptop use and the skills measured by the most widely used standardized tests. (p.4, Rockman *et al.* 2000)

A lack of match between the tools used by students, and the tools used in the assessment of student outcomes, is commented on by other researchers (Gardner *et al.* 1993; Boyd 1997), and in overviews of this area (Fouts 2000).

Indicators that are specifically tailored to the goals of an initiative and to the way ICT is being integrated into the classroom, such as the ability to handle mathematics and science data (as developed by Passey *et al.*, 2001), appear to be more valid indicators of the impact of a ICT innovation than generic achievement tests.

Pucel (2001) proposed a change in the types of indicators used to measure the effectiveness of vocational and academic education programmes. This change is directly related to the shift in school goals as a result of the societal shift from the information age to the knowledge age. Pucel's suggestions appear to be applicable to ICT innovations in schools. He suggested that societies' current expectations of students are that they:

- Be able to creatively solve problems;
- Be able to apply what they learn to their future lives and work;
- Have a rigorous background in academic skills;
- Develop generalized employability skills;
- Explore and become technologically literate on potential careers;
- Develop visions of their futures and how their education's can contribute to those visions. (p.ix, Pucel 2001)

Pucel considered that widely used indicators such as academic tests (for example, the Scholastic Aptitude Test (SAT)) are not valid indicators of vocational programme success. He suggested a number of indicators that could be used to "realign educational practice with reform expectations". These are:

- Student retention and satisfaction.
- Academic skill development and contextual problem-solving, that is, how students can apply academic skills to real-life situations.
- Career exploration and skill development.
- Employability skill development, e.g., that the student has developed competencies such as: information literacy skills, technology and ICT skills, understanding of systems, and the ability to work with others.

A similar suggestion was made by Penuel and Kim (2000) in relation to CTC programmes. They noted that better tools are needed to measure CTC programme outcomes as traditional measures of successful outcomes, such as test results, are not appropriate for CTCs. Measures are needed which are more closely tied to the specific goals of the centre, for example, how programmes impact on clients' learning or measurement of clients' career aspirations, pathways, or technical skills.

Reoccurring concerns for school-based projects

Dr Eva Baker (quoted in Spielvogel *et al.* 2001) suggested that anyone could write an evaluation summary of a school-based ICT project without actually visiting the site; this summary would be "This project has real potential if only it had been implemented more fully." (p.6, Spielvogel *et al.* 2001).

Although this quote is somewhat sobering, it seemed particularly relevant to the laptop school projects and some of the study centre and resource development projects in the review. A lack of professional development, and in many cases technical support, was a concern mentioned repeatedly by teachers. The professional development that teachers suggested that they needed more of was based around pedagogy and integrating ICT use into the classroom rather than simply developing ICT skills. Other issues of relevance to many of the projects located in low-income environments were sustainability and continued funding.

Targeting digital divide policies

Commentators have criticised digital divide research as being too focused on access to technology at the expense of examining how the technology can be used to assist low-income individuals and groups to better their situation. A re-focus on narrowing the social divide rather than the digital divide is suggested by these commentators (Kirschenbaum & Kunamneni 2001; Morino Institute 2001). In the report *From Access to Outcomes,* Morino Institute (2001) concluded that providing access alone is more well-meaning than effective. The report suggested that initiatives developed by low-income communities to address their immediate issues and concerns are far better at producing meaningful change as communities use the

technology to meet tangible social, economic, or educational goals, such as effective schooling or access to improved healthcare.

A similar suggestion was made by Lazarus and Mora (2000) who reported that apart from a lack of access, there is one other main barrier for low-income groups in using the Internet, that is, a lack of relevant content. Lazarus and Mora analysed discussions with 107 low-income adults, youths, and children, interviews with people involved in providing online access and information to low-income groups, and current web content. From this research they suggested that Americans on the wrong side of the digital divide wanted:

- local information regarding employment, business, education, and other areas;
- information that can be understood by low-literacy users;
- information in the languages of the local community and in multiple languages; and
- opportunities to create content and interact with it in culturally appropriate ways.

Essentially digital divide research appears to suffer from a similar problem to the larger body of knowledge surrounding ICT innovations, it is dogged by concerns about "what" (that is, access and infrastructure) at the expense of questions concerning "how" people use the technology and "why" access can be beneficial.

Suggestions for designing evaluations of ICT initiatives in schools

Most evaluations discussed in the review were in the form of two- or three-year longitudinal multi-method case studies of either a single site or multiple sites. The literature surrounding the selection of research or evaluation methods suggests that this is a valid approach for these types of initiatives. The longitudinal evaluations, which were longer than one year in timeframe, yielded richer results and more certain conclusions than other designs such as snapshot studies.

Most of the evaluations in this study were either process and/or outcome focused; some included a cursorily formative component. From the information summarised in the review it is evident that an increased emphasis on formative evaluation would benefit school-based ICT projects, in that the much reported problems in the literature with inadequate professional development and support could be identified and rectified early on in the life of the programme – given available funding. Formative evaluation could also assist to clarify project goals, and from that, evaluation goals. Process evaluation of pilot programmes are useful tools which could enable others to emulate the programme.

A continued focus on outcome evaluation is also necessary to ensure that the programme is in fact making a difference to teaching and learning. Outcome evaluations need to avoid the "black box" approach by examining the "how" and "why" rather than the "what". Evaluations that document the experiences of people in low-income communities need to examine more than just increased access. As suggested by the Morino Institute (2001), projects, and therefore their evaluations, should include a focus on what needs low-income communities are addressing through accessing technology, and how these needs are met. Other features of future evaluation could include:

- Research questions that encourage the evaluation to consider the complex conditions and interactions that support successful programmes.
- In line with the suggestions offered by Pucel (2001) and Penuel and Kim (2000), evaluations could include a re-examination of the indicators used to ensure that they match the skills required of the "information age".
- Development of measures that are clearly related to the goals of the projects, rather that relying on standardised tests results to indicate programme success.

- An inclusion of some of the extra indicators commonly used to examine the success of initiatives in low-income communities, such as improvements in student retention data, development of student career goals, increased community access to ICT, increased communication between home and school and involvement of parents and the community in the education of their children, or improved behaviour.
- A design that includes the viewpoints of the multiple stakeholders involved in a project.
- A design that ensures that at least two sources of data are used to corroborate self-reported evidence, for example, the inclusion of observational analyses of behaviour.

REFERENCES

Ainley, M., *et al.* (2000). *Computers, laptops and tools.* Melbourne: Australian Council for Educational Research.

Bain, A. (1996). The School Design Model at Brewster Academy: technology serving teaching and learning. *T.H.E. Journal*, 23 (10), at: http://www.thejournal.com/magazine/vault/A551.cfm

Barker, B. (2001). *Maori access to information technology*. Wellington: Te Puni Kokiri, Ministry of Maori Development.

Boyd, S. (1997). *Learning by bytes: computers in the classroom*. Wellington: New Zealand Council for Educational Research.

Boyd, S. (2001). *Literature review for the digital opportunities projects. Report to the Ministry of Education.* Wellington: New Zealand Council for Educational Research. (In press.)

Bragg, D. (2001). *Promising outcomes for Tech Prep participants in eight local consortia.* St. Paul, Minnesota: National Research Center for Career and Technical Education, at: http://www.nccte.org/publications/infosynthesis/r&dreport/Promising%20Outcomes.pdf

Breeden, L., *et al.* (1998). *Computer and communications use in low-income communities: models for the neighborhood transformation and family development initiative.* Newton, MA: Education Development Center, at: http://www.ctcnet.org/casey/

Culp, K., Hawkins, J., & Honey, M. (1999*). Review paper on educational technology research and development*. New York: EDC/Center for Children and Technology, at: http://www2.edc.org/CCT/cctweb/public/include/pdf/01_1999.pdf

Dynarski, M., *et al.* (2001). *A broader view: the national evaluation of the 21st Century Community Learning Centers Program. Design report, volume 1.* Princeton, NJ: Mathematica Policy Research, Inc, at: http://www.mathematica-mpr.com/PDFs/broadviewvol1.pdf

Fashola, O. (1998). *Review of extended-day and after-school programs and their effectiveness.* Baltimore, MD: Center for Research on the Education of Students Placed At-risk, Johns Hopkins University, at: http://www.csos.jhu.edu/crespar/Reports/report24.pdf

Fisher, D., & Stolarchuk, E. (1998). The effect of using laptop computers on achievement, attitude to science and classroom environment in science. Proceedings of the *Western Australian Institute for Educational Research Forum.* Perth: Curtin University of Technology, at: http://education.curtin.edu.au/waier/forums/1998/fisher.html

Fouts, J. (2000). *Research on computers and education: past, present, and future*. Seattle: Bill and Melinda Gates Foundation, at: http://www.gatesfoundation.org/learning/ed/research/found_spon_research.htm

Gardner, J., *et al.* (1993). *Personal portable computers and the curriculum*. Edinburgh: Scottish Council for Educational Research.

Henriques, A., & Ba, H. (2000). *Project Connect: bridging the digital divide. Final evaluation report*. New York: EDC/Center for Children and Technology, at: http://www2.edc.org/CCT/cctweb/public/include/pdf/07_2000.pdf

Hill, J., *et al.* (2000). *The impact of portable technologies on teaching and learning: Year one report.* Athens, GA: University of Georgia at: http://lpsl.coe.uga.edu/Projects/Aalaptop/image/pdf/year1report.pdf

Jackson, S., & Guerin, J. (1999). *Louisiana Challenge Grant. Five model classrooms: A case study.* Louisiana: the Louisiana Challenge Grant, at: http://www.challenge.state.la.us/eval/case_study.html

Kessell, S. (2001). *Evaluation of the personal laptop program at Penrhos College (1998-2000).* Perth: Curtin University and Penrhos College at: http://learnt.smec.curtin.edu.au/Common/Penrhos/

Kirschenbaum, J., & Kunamneni, R. (2001). *Bridging the organizational divide: toward a comprehensive approach to the digital divide*. Oakland, CA: PolicyLink, at: http://www.policylink.org/publications.html

Latino Issues Forum. (2000). *The rural technology and information project: addressing the digital divide at the front lines of underserved communities*. San Francisco: Latino Issues Forum, at: http://www.lif.org/sig.html

Latino Issues Forum. (2001). *Model for closing technological and educational disparities in underserved communities.* San Francisco: Latino Issues Forum, at: http://www.lif.org/tech_update.html

Lazarus, W., & Mora, F. (2000). *Online content for low-income and underserved Americans: the digital divide's new frontier*. Santa Monica, CA: The Children's Partnership, at: http://www.childrenspartnership.org/

Macias, E., *et al.* (2000). *The Digital Steppingstones Project: research results.* A paper prepared for the Digital Steppingstones Conference: Smart Strategies for Underserved Communities in the Information Age November 16, 2000, at: http://www.trpi.org/dss/research.html

Michalchik, V., & Penuel, W. (2001). *Outcome evaluation framework: measuring the impacts of the Community Technology Centers program*. Menlo Park, CA: SRI International.

Ministry of Education. (2001a). *Digital Opportunities contract, project 4.* Wellington: Ministry of Education.

Ministry of Education. (2001b). *Information and communication technologies (ICT) strategy for schools, 2002-2004 draft*. Wellington: Ministry of Education, at: http://www.minedu.govt.nz/web/document/document_page.cfm?id=5923#P229_21191

Morino Institute. (2001). *From access to outcomes: raising the aspirations for technology initiatives in low-income communities*. Reston, VA: Morino Institute, at: http://www.morino.org/divides/report.pdf

NetSchools Corporation. (accessed 13/8/01). *NetSchools constellation case studies.* Atlanta, GA: NetSchools Corporation at: http://netschools.com/PDFs/NetSchoolsConstellationCaseStudies.pdf

New Economy Development Group Inc. (1998). *Models of community learning networks in Canada*. Hull, Quebec: Office of Learning Technologies, at: http://olt-bta.hrdc-drhc.gc.ca/download/CLNmod_e.pdf

Newhouse, P. (1999). Portable computers supporting secondary school learning. Proceedings of the *Western Australian Institute for Educational Research Forum 1999*. Perth: Curtin University of Technology at: http://education.curtin.edu.au/waier/forums/1999/newhouse.html

OECD. (2000). *ICT and the quality of learning: methodology for case studies of organisational change.* Newark, DE: OECD/CERI Schooling for Tomorrow, at: http://bert.eds.udel.edu/oecd/cases/casesframe.html

Owen, J., & Lambert, F. (1996). The notebook curriculum: An innovative approach to the use of personal computers in the classroom. *Australian Educational Computing*, 11(1).

Parr, J. (1992). *Report of the evaluation of the desktop and laptop project at King's College*. Auckland: Education Department, University of Auckland.

Parr, J. (1993). *Report of the King's College computer project 1992*. Auckland: Education Department, University of Auckland.

Parr, J. (2000). *A review of the literature on computer-assisted learning, particularly integrated learning systems, and outcomes with respect to literacy and numeracy. Final report.* Auckland: Auckland Uniservices Limited.

Passey, D., *et al.* (1999). *Anytime, anywhere learning pilot programme: A Microsoft UK supported programme in 28 pilot schools. The overview report.* Lancaster: Lancaster University at: http://www.microsoft.com/uk/aal/findings.htm

Passey, D., *et al.* (2001). *Anytime, anywhere learning pilot programme: A Microsoft UK supported laptop project. Learning gains in year 5 and year 8 classrooms. Executive summary*: Lancaster University at: http://www.microsoft.com/uk/aal/findings.htm

Penuel, W., *et al.* (2001). The organization of learning in community technology centers: learning with technology in six communities. Paper presented at the *Annual Meeting of the America Educational Research Association*, April 10-14, Seattle, Washington, at: http://www.sri.com/policy/ctl/assets/pdfs/vstaera2001.pdf

Penuel, W., & Kim, D. (2000). *Promising practices and organizational challenges in Community Technology Centers*. Menlo Park, CA: VStreets Research Group, SRI International, at: http://www.sri.com/policy/ctl/assets/images/vStreets_Promising_Practices.pdf

Polesel, J., Teese, R., & O'Brien, K. (1999). *Two years out: the class of 1997.* Melbourne: Department of Education, Employment and Training, Victoria, at: http://www.sofweb.vic.edu.au/voced/research/pdf/VET_97(txt).pdf

Pucel, D. (2001). *Beyond vocational education.* Larchmont, NY: Eye on Education, Inc.

Raphael, J., & Chaplin, D. (2000). *Formative report on the DC 21st Century Community Learning Center after-school program*. Washington D.C.: Urban Institute, at: http://www.urban.org/pdfs/dc_21st_century.pdf

Ricci, C. (1999). Program evaluation: The New York City Board of Education Community School District Six laptop project. Paper presented at the *American Educational Research Association (AERA) conference*, Montreal, Canada, April 19-23.

Robertson, S. *et al.* (1997). The use and effectiveness of palmtop computers in education. *British Journal of Educational Technology*, 28(3), pp.177-189.

Rockman *et al.* (2000). *A more complex picture: laptop use and impact in the context of changing home and school access*. San Francisco, CA: Rockman *et al.*, at: http://rockman.com/projects/laptop/

Rowe, H. (1993). *Learning with personal computers*. Melbourne: Australian Council for Educational Research.

Schacter, J. (1999). *The impact of education technology on student achievement: what the most current research has to say*. Santa Monica, CA: Milken Family Foundation, at: http://www.mff.org/publications/publications.taf?page=161

Selby, L., Elgar, S., & Ryba, K. (2001). An evaluation of the St Cuthbert's Junior School College laptop project. In *Computers in New Zealand Schools*, 13(1), pp.29-38.

Shears, L. (Ed.) (1995). *Computers and schools*. Melbourne: Australian Council for Educational Research.

Spielvogel, R., *et al.* (2001). *IBM's reinventing education grant partnership initiative. Individual site reports*. New York: EDC/Center for Children and Technology, at: http://www2.edc.org/CCT/cctweb/public/include/pdf/ibmsite.pdf

Stevenson, K. (1999). *Evaluation report – year 3, middle school laptop program, Beaufort County School District. Executive summary*. Beaufort, South Carolina: Beaufort County School District at: .http://www.beaufort.k12.sc.us/district/evalreport3.htm

Stradling, B., *et al.* (1994). *Portable computers pilot evaluation summary*. Coventry: National Council for Educational Technology.

Tyner, K. (2000). *SURWEB summative evaluation report 1995-2000*. San Francisco, CA: Media, Analysis & Practice, at: http://www.surweb.org/evaluation/index.htm

Venezky, R., & Davis, C. (2001). *Quo Vademus? The transformation of schooling in a networked world. Version 3e.* Newark, DE: OECD/CERI Schooling for Tomorrow, at: http://bert.eds.udel.edu/oecd/cases/casesframe.html

Wood, D., Underwood, J., & Avis, P. (1999). Integrated learning systems in the classroom. *Computers and Education*, 33, pp.91-108.

Woodbridge, S. (2000). *Norwood School laptop and technology program evaluation final report*. Bethesda, MD: Norwood School, at: http://www.norwood.pvt.k12.md.us/uploads/Laptop_Evaluation_Full.pdf

Yin, R. (1994). *Case study research: design and methods (second edition)*. Thousand Oaks: Sage Publications Inc