A Meta-Synthesis of Research on 1:1 Technology Initiatives in K-12 Education

G. Roger Sell, Jeffrey Cornelius-White, Ching-Wen Chang,
Annice McLean, & W Roy Roworth

Ozarks Educational Research Initiative
Institute for School Improvement
Missouri State University
April 30, 2012

Acknowledgements

The authors wish to thank the following for their collaboration and support in completing the report of this review of research on one-to-one educational technology initiatives:

Dennis Kear
Dean
College of Education
Missouri State University

Alex Inman
Senior Collaborator
Educational Collaborators
Washington, DC

Fred Czerwonka
Superintendent
West Plains Public Schools
West Plains, MO

Dan Decker
Superintendent
Aurora Public Schools
Aurora, MO

Janice Duncan
Principal
Greenwood Lab School
Springfield, MO

CJ Huff
Superintendent
Joplin Public Schools
Joplin, MO

John Jungmann
Superintendent
Monett Public Schools
Monett, MO

Steve Kleinsmith
Superintendent
Nixa Public Schools
Nixa, MO

Michael Mason
Superintendent
Reeds Spring Public Schools
Reeds Spring, MO

Mark Mayo
Superintendent
Marshfield Public Schools
Marshfield, MO

Kent Medlin
Superintendent
Willard Public Schools
Willard, MO

Steve Morgan
Superintendent
Bolivar Public Schools
Bolivar, MO

Gordon Pace
Superintendent
Ozark Public Schools
Ozark, MO

Norm Ridder
Superintendent
Springfield Public Schools
Springfield, MO

Brad Swofford
Assistant Superintendent
Branson Public Schools
Branson, MO

Tim Taylor
Superintendent
Hollister Public Schools
Hollister, MO

Jeremy Tucker
Superintendent
Logan-Rogersville Public Schools
Rogersville, MO

Duane Widhalm
Superintendent
Lebanon Public Schools
Lebanon, MO

Abstract

Initiatives for one-to-one educational technology (1:1), one computer device per student, have become increasingly common in K-12 education. Beginning in 2011, the Ozarks Educational Research Initiative (OERI)—a cooperative partnership among 15 schools districts, a laboratory school, and the Institute for School Improvement at Missouri State University—began a multi-year project focused on research into effective practices for using digital technologies to enhance student learning and school effectiveness. As part of that project, the OERI Advisory Council requested the Institute to conduct a "meta-analysis" of research on 1:1 technology initiatives to inform member districts and to help guide related research activities for the project. Council members generated 15 questions of interest for the research review. While several research reviews are available in the literature, they are dated in a field that is highly sensitive to recency effect. Likewise, information on certain student outcomes, implementation concerns, and funding strategies related to the Council's questions of interest is sparse or lacking in published systematic reviews. The current research review aims to address these issues, synthesizing available literature while attending to the quality of research for each of these three broad domains. This meta-synthesis used a systematic process for searching, identifying, excluding, selecting, and assessing relevant research. The authors identified and analyzed four systematic reviews of research, which included 131 total unduplicated studies, focused on 1:1 educational technology; five additional systematic reviews of research that included but went beyond 1:1 educational technology; and 24 other reviews of 1:1 technology initiatives in K-12 education. Findings and conclusions of these selected reviews were coded and analyzed according to their strength of evidence. Overall, laptops rather than other kinds of devices are the focus for systematic reviews of 1:1 technology research through 2011. We found evidence in our systematic reviews that writing is the area of student achievement with the largest and most consistently positive impact in 1:1 initiatives compared to other student outcomes that have mixed results or weak evidence. The most consistent findings for implementation impact in 1:1 educational technology initiatives include provision of thorough, staged professional development, infrastructure and technical support, district-school-teacher leadership and collaboration for student-centered teaching methods and applications, and the need for ongoing research and evaluation of 1:1 initiatives. Key funding issues include securing sufficient financial sources, usually from multiple sources, for the initial acquisition as well as the sustainability and upgrading of 1:1 resources. Findings from our meta-synthesis, including strength of supporting evidence, are compared to those of industry-sponsored Project RED, which conducted a large-scale survey and published in 2010 widely disseminated results regarding the impact of 1:1 technologies in K-12 education. In moving forward, the overall "big" question for 1:1 technology initiatives involves cost-benefit or return on investment (ROI) in relation to practices without 1:1 technology and other educational innovations. All of these sources and findings contributed to development of a framework and agenda for future OERI research that is presented in this report.

Introduction

Ubiquitous computer access has become a goal for many school districts and a frequent topic of research and debate in the past two decades. Billions of dollars have been spent in educational technology working towards this potential end. For example, $650 million was spent by the federal government alone for just one grant program in 2009, the Enhancing Education Through Technology program (Bakia, Means, Gallagher, Chen and Jones, 2009). Drawing on federal funds as well as state and local financial resources, states such as Florida, Maine, Michigan, North Carolina, South Dakota, and Texas have initiated and operated large-scale 1:1 technology programs (Holcomb, 2009; Argueta, et al., 2011). Based on experiences such as these states, guidebooks have been developed for the planning and implementation of 1:1 technology initiatives (e.g., Alberta Education, 2010; Wilson & Gielniak, 2011). Weston and Bain (2010) described how enthusiastic rhetoric about 1:1 technology will transform education and they discussed provocative questions about the cost-benefit ratio and lack of solid evidence for such initiatives. Multiple attempts have been made to describe and interpret the research on 1:1 technology initiatives in order to settle some of these concerns, many of which are described below.

Policymakers and educators strive to make effective use of technologies that are changing dramatically from year to year. In doing so, they may rely on word of mouth or industry reports rather than solid research designed for objective and replicable findings. However, there is often a significant delay in the availability of research to assess the impact of a particular technology implemented in educational settings. For example, a superintendent might read in 2012 a "recent" literature review that was published in 2011 to prepare for a 1:1 initiative for fall 2013. The review read by the superintendent might summarize findings from studies published mostly in the early- to mid-2000s. It is likely that studies published in this earlier period investigated technologies that are no longer available or have been significantly changed with regard to differences in computer capability, usage by students and teachers, wireless and internet technology, pricing, applications available, and myriad other considerations different from what existed seven or more years ago. In other words, the findings from research on 1:1 educational technology initiatives have inherent limitations that reflect a particular time period, local and cultural context, set of practices, and available technologies.

The objective of this report is to synthesize information from existing research reviews, individual studies, and state and local initiatives to address several questions related to the state of the art in 1:1 technology initiatives. The authors used differing methods to address specific questions depending on the state of development of the literature. When a question had been addressed sufficiently in the literature through existing meta-analyses and other systematic reviews, a reasonable level of confidence could be supplied. In other instances, only non-systematic reviews drawing on a set of self-selected studies of uncertain quality could be found. Overall, the authors aimed to provide a description of the procedures used to identify and select research studies along with the analysis, findings, and suggestions for "best practice" or future research based on the highest quality information available.

Defining 1:1 Educational Technology

To anchor the review of research on 1:1 technology initiatives, the following definition was adapted from descriptions by Penuel (2006) and Zucker & Light (2009). 1:1 means one computerized device per student. Currently, 1:1 educational technologies in K-12 education are:

- wireless;
- accessible to the Internet and at least one local school network;
- equipped with software and support for classroom instruction, homework, tests, feedback, presentations, social networking, and productivity applications (e.g., word processing and spreadsheets);
- available for use 24 hours a day, 7 days a week; and
- compatible with digital tools and resources such as online courses, interactive whiteboards, and probes for data collection and science experiments.

This description captures the variety of 1:1 technologies that have been discussed within the literature and local context (See "Context" section on page 6). Some examples of 1:1 technology devices are laptops, tablets, netbooks, smart phones, and small hand-held devices (e.g., iPOD Touch).

What Is a Meta-Synthesis?

Meta-synthesis is one kind of systematic review of research for the purpose of summarizing what can be learned from prior studies that meet particular selection and quality criteria. Kahn, et al. (2003) define a systematic review as follows:

> A review earns the adjective systematic if it is based on a clearly formulated question, identifies relevant studies, appraises their quality and summarizes the evidence by use of explicit methodology. It is the explicit and systematic approach that distinguishes systematic reviews from traditional reviews and commentaries. (p. 118)

Bethel and Bernard (2010) add the synthesis component to the general definition of a systematic review:

> Research synthesis is the process through which two or more research studies are assessed with the objective of summarizing the evidence related to a particular question. . . . The goals of a research synthesis that attempts to answer the 'what works' question is to aggregate the existing research on a particular question and draw general conclusions from the research evidence that it encompasses. (p. 232)

They go on to outline the general characteristics of a research synthesis (Bethel and Bernard, 2010, p. 232):

- Systematic—step-by-step iterative approach to the method
- Comprehensive—encompasses all available relevant research
- Critical—appraises the nature of evidence and selects appropriate
- Objective—minimizes bias at each step
- Rigorous—applies the strictest standards or states why exceptions apply
- Transparent—subjects every important detail to scrutiny
- Replicable—repeatable by other researchers to see if conclusions hold
- Integrative—reaches general conclusions or states why this cannot be done
- Explanatory—relates findings to theory/practice
- Relevant—adds value to researchers, theorists, practitioners, and/or policymakers

Bethel and Bernard also note that meta-synthesis is a methodology that can be used for "synthesizing syntheses" or synthesizing meta-analyses, using procedures and criteria common to other systematic reviews of research. In addition to evaluating and synthesizing information from reviews that satisfy these thorough criteria, much information can be gleaned from less systematic reviews, particularly in areas of research that have not matured sufficiently to have had a meta-analysis conducted. Likewise, some individual reports may provide insights, findings, or recommendations in an area that has been only barely studied. Finally, practical experience and anecdotal information can provide suggestions in areas with no available empirical research.

Context

The Ozarks Educational Research Initiative (OERI) is a collaborative partnership between member school districts in the State of Missouri and the Institute for School Improvement at Missouri State University. The purpose of the OERI collaboration is to undertake joint research and development projects, and to use results from projects, to improve student learning and school effectiveness. OERI members in 2011-2012 included 15 member public school districts and one laboratory school in Southwest Missouri. The OERI members are (alphabetically): Aurora, Bolivar, Branson, Greenwood Laboratory School, Hollister, Joplin, Lebanon, Logan-Rogersville, Marshfield, Monett, Nixa, Ozark, Reeds Spring, Springfield, West Plains, and Willard. The communities served by OERI school districts are diverse. OERI members represent a wide range of K-12 schools located in smaller, rural communities as well as larger suburban and urban communities. The total enrollment of OERI school districts in January 2011 was 74,011; the district enrollments ranged from 1,368 to 24,102 for an average enrollment of 4,934. The Greenwood Laboratory Schools enrolls about 350 students and the Springfield Public Schools enrolls the largest number of students among accredited public school districts in the State of Missouri. Across the 15 school districts, the non-white enrollment ranged from 5% to 31%, and the non-white enrollment among total students was 13%. One-half (50%) of the students enrolled in OERI districts in FY2011 qualified for free or reduced-price lunch, and the range across districts was 34% to 69%. The combined 15 school districts operated 153 separate elementary schools, middle schools, high schools, and specialty schools.

OERI activities are implemented through projects selected by an advisory council composed of member representatives (i.e., superintendents or their designees). The 1:1 technology initiative approved by the OERI Advisory Council is presented below:

> The target project for 2011-2013, "The Road to One to One: 21st Century Teaching and Learning," will focus on research into effective practices for using digital technologies to enhance student achievement and school effectiveness. This project is based on the following assumption: In the next three to five years, public schools will accomplish great strides toward evolving instruction to incorporate digital capabilities that support 1:1 technology, i.e., one technology device for one student. If this assumption is correct, then school districts will need to develop and implement strategies for accomplishing this effort. This project will identify and analyze "best practices" according to available research and local initiatives from the perspective that student achievement is the goal, instructional pedagogy is the focus, and technology is the accelerator. The results of the study will include district self-assessment, recommendations to districts for specific transition needs and requirements, and collaboration across and between districts. This intentional collaboration may yield opportunities for inter-district professional development and collective purchasing. Implementation of the project will be based on a committee structure led by OERI superintendents (or their designees) and include district representatives and consulting faculty. The initial committees identified for project implementation include: instruction and professional development; virtual learning; business/community partnerships; policy, procedures, law, and legislation; funding and budgeting; and hardware and infrastructure. In addition to action research within OERI districts, at least one cross-district event (showcase and/or conference) will be held each of the two years of the project to share experiences and research findings across districts. OERI member districts also will be encouraged to participate in project-related publications and professional conference presentations.

More specific to this review, the OERI Advisory Council requested that the Institute for School Improvement conduct a "meta-analysis" of research on 1:1 technology initiatives to inform member districts and to help guide related research activities for the project.

This report responds to the OERI Advisory Council request for a meta-analysis by synthesizing a systematic review of studies contributing to a knowledge base for conducting 1:1 initiatives. We describe our review as a meta-synthesis aimed at uncovering and highlighting reliable information and recommendations for developing an empirically grounded set of "best practices" for 1:1 technology initiatives.

Research Questions

Figure 1 shows the research questions addressed in this review of research on 1:1 technology initiatives in K-12 education. Consistent with the collaborative process of OERI, the authors requested up to three questions from each of the committees of the 1:1 project (instruction and professional development; virtual learning; business/community partnerships; policy, procedures, and law; funding and budgeting; and hardware and infrastructure) and the 15 school district superintendents and laboratory school director. This bottom-up process yielded 15 questions of interest, some of which overlapped, as shown in Figure 2. The 15 questions were condensed into three topic questions and one general research question. The broad research question concerns the outcomes, implementation, and funding of 1:1 technology initiatives.

Figure 1. Questions of Interest from OERI 1:1 Technology Initiative Committees and Superintendents

A. Business and Community Partnerships Committee

1. Does the proper use of "1:1 technology" improve student learning in the basics (i.e. reading, writing, and math)?
2. What "1:1 technology" for students is the best to use if one wishes to improve student achievement for all student groups?
3. What steps (e.g., PD) does a district need to take in order to properly implement "1:1 technology" to the point school districts get a return on their investment (improved academics)?

B. Funding and Budgeting Committee

1. Is the 1:1 initiative more effective and efficient than the use of textbooks and other materials?
2. What process will work best to fund the deployment of the 1:1 initiative?
3. What are the training and deployment costs for an effective 1:1 initiative?

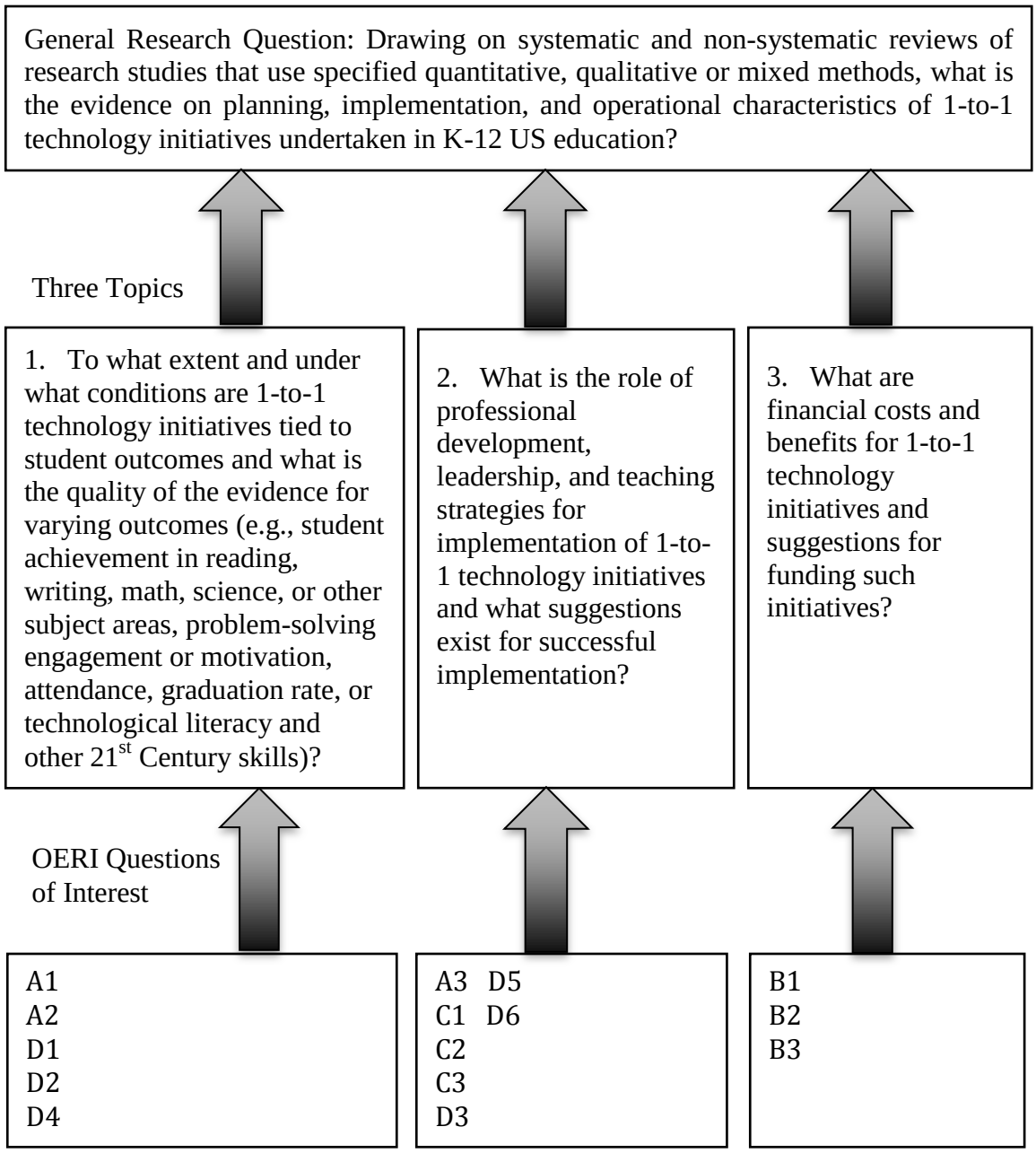
C. Instruction and Professional Development Committee

1. What are the best research-based practices to implement and sustain professional development by utilizing technology that is developmentally appropriate for grades Pre-K through postsecondary education?
2. What instructional technology tools are being used effectively by districts that are currently engaged in 1 to 1 technology?
3. How do we integrate effective use of technology with best practices for maximizing student achievement?

D. Individual OERI Superintendent Questions

1. Where is the evidence of increased academic achievement for students who participate in 1:1 programs?
2. How do the results of effectiveness of 1 to 1 technology compare with students of similar demographics who are not using 1 to 1 technology?
3. What professional development opportunities/activities have been identified as the most successful to assist teachers as they begin the 1:1 process? And how was the PD implemented?
4. Does research really show that engagement and attendance increases while discipline decreases in schools with 1:1 programs? How about graduation rates?
5. How are concerns for leadership, change, curriculum, and assessment addressed in the research on 1:1 technology initiatives?
6. What are the main concerns for virtual learning/online learning/blended learning in 1:1 initiatives?

Figure 2. Relationships between the General Research Question, Three Topic Questions and 15 Specific Committee Questions



Methodology

This project used various methods to address the questions at hand, emphasizing the identification, evaluation, and reporting of higher quality information where available.

Procedures and Criteria of the Meta-Synthesis

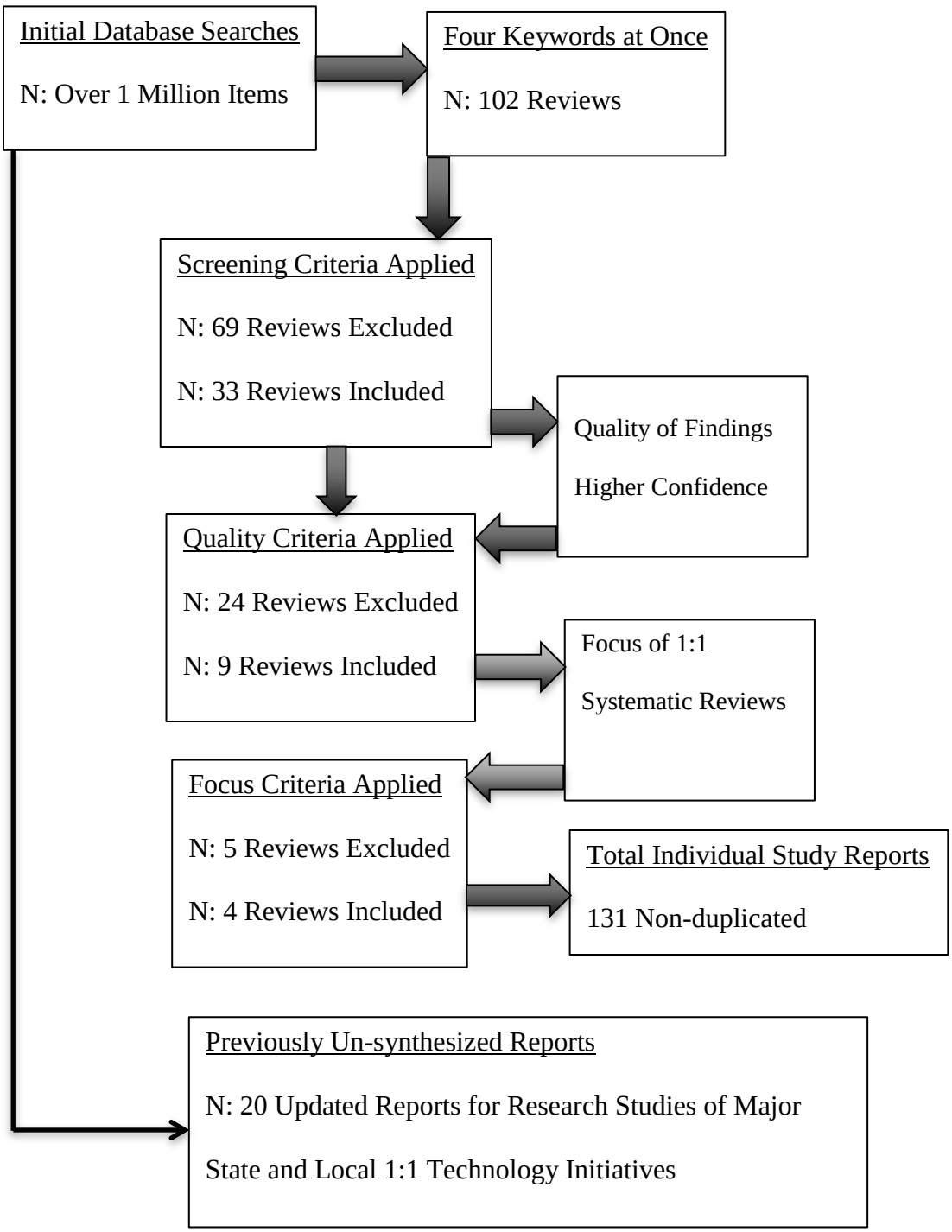
The meta-synthesis involved the following procedures: (1) searching and retrieving available research reviews of 1:1 technology projects from selected data bases (using relevant keywords) as well as from related websites and other sources of potentially relevant journal articles, project reports, conference papers, etc.; (2) screening retrieved reviews to select those meeting the criteria for inclusion in the quality assessment phase; (3) applying assessment criteria for those reviews meeting the screening criteria to assure that reviews highlighted in the meta-synthesis met the explicit qualities of systematic reviews; (4) using meta-synthesis procedures with the selected final set of four systematic research reviews to compile, analyze, summarize, and report methods and findings; (5) where topics were insufficiently addressed by the focused systematic reviews, returning to the set of five studies which made it past the screening and quality assessment criteria but where the focus was broader than one to one technology initiatives, as well as 20 recent, non-synthesized individual reports, and 24 practical, non-systematic review articles to find literature addressing these topics; and (6) addressing any remaining topics through positing potential research that could address these topics.

Searching and Retrieving Research Reviews

Figure 3 provides an overview of the search and selection process. Descriptors (keywords) used in the search strategy included: 1:1; 1-to-1; 1:1; technology; educational technology; computers; computer technology; computing; ubiquitous; devices; handheld devices; laptops; netbooks; iPads; electronic devices; K-12 education; elementary education; secondary education; elementary school; middle school; high school; initiatives; projects; programs; mobile learning; learning with technology; research; research review; meta-analysis; meta-synthesis; systematic review. The authors utilized the following databases with these descriptors: ERIC; ebooks/EBSCOhost; Education Full Text; and PSYCarticles. The search engines for Google and Google Scholar were used to locate additional research reviews. The initial search yielded an unwieldy large number of potential sources that included not just books and peer-reviewed journals, but also project reports and articles written in more accessible styles for practitioners with suggestions and current information in a rapidly changing field not covered in traditional educational research sources. For example, using the descriptor "1:1 technology" a Google Scholar yielded 1,780 items while a Google search showed 1,270,000 sources. Therefore, the researchers decided to use at least four descriptors in various combinations within all of these databases and search engines:

- 1:1 (or a variation thereof, i.e., one-to-one or 1-to-1);
- technology, computer, and/or initiative;
- review, research review, or systematic review; and
- planning, implementation or operations.

Figure 3. Flowchart of the systematic review selection process



Likewise, we only considered sources primarily concerned with K-12 education rather than higher education.

The following websites also were searched in the effort for relevant resources beyond those found in traditional sources:

Government of Alberta: Education. (2012). Retrieved from http://education.alberta.ca/admin/technology/emerge-1:1.aspx/
Anytime, Anywhere Learning Foundation. (n.d.). Retrieved from http://www.aalf.org/
Consortium for School Networking. (n.d.). Retrieved from http://www.cosn.org/
Irving Independent School District. (n.d.). Documents for 1-to-1 laptop distribution. Retrieved from http://www.irvingsd.net/one2one/documents.htm/
K-12 Computing Blueprint. (2010). Retrieved from http://www.k12blueprint.com/k12/blueprint/index.php
Maine International Center for Digital Learning. (2012). Retrieved from http://www.micdl.org/
One Child Per Laptop. (n.d.) Retrieved from http://one.laptop.org/
Project RED: Revolutionizing Education. (2009). Retrieved from http://www.projectred.org/
Rockman, et al. (2012). Retrieved from http://www.rockman.com/
State Educational Technology Directors Association. (2008). Retrieved from http://setda.org/
Tech & Learning. (2012). Retrieved from http://www.techandlearning.com/index/
Ubiquitous Computing Evaluation Consortium. (2003). Retrieved from http://www.ubiqcomputing.org/lit_review.html

References cited in the retrieved research reviews were also used to identify additional potential items to include for screening.

As a result of this extensive search for relevant documents that were published or posted by the end of December 2011, 102 potential research reviews of 1:1 technology studies were identified. These reviews were then screened for inclusion in the meta-synthesis. Additionally, many articles were identified which had some relatively minor "review of the research" section that did not constitute a full review. The intent in considering these additional articles was to see which articles might be non-duplicated after completion of the steps to screen, assess quality, and determine 1:1 focus, with an eye toward practical information for addressing some of the specific topics not covered in depth in full reviews. Finally, recency effect is of utmost importance given the rapid pace of technology advances, usage increases, and the relative delay in conducting, publishing, and accessing research. Therefore, the authors also collected a set of non-duplicated, recent reports not included in earlier focused systematic syntheses. A synthesis of these project-specific studies is not included in this review but will be reported at a later date.

Screening Retrieved Reviews

The screening criteria shown in Table 1 were applied to the 102 retrieved research reviews to identify which ones addressed the major features of the research question guiding the meta-synthesis. References to these sources are included in the References section and are marked with a superscript number after each reference to designate

Table 1. Screening Criteria for Selection of Research Reviews for Quality Assessment

Include these Research Reviews for Full Review	**Exclude these Research Reviews from Full Review**
Focus is on review of research studies of 1:1 technology initiatives (at classroom, school, district, state, or national level)	Focus is not on review of 1:1 technology initiatives although a small portion of the studies reviewed may be 1:1
The context for reviewed studies is school-based	Reviewed studies are not in K-12 environments
The preponderance (e.g., 75% or more) of reviewed studies are in US education	The reviewed studies are international in scope although a small portion may be from the US
The review is based on empirical evidence using quantitative and/or qualitative methods	The review is based primarily on personal opinions or personal observations
Reviewed studies collect project data over a period of at least one semester (i.e., 16 weeks)	Studies reviewed included projects that lasted less than one semester.
Reviewed studies include the impact of 1:1 technology use on at least one type of student outcomes, such as knowledge, skills, attitudes, engagement, attendance, or disciplinary behavior	A significant number of the reviewed studies do not include the impact of one-to-technology use on student outcomes
Reviewed studies include at least one of the following activities regarding impact on student outcomes: 1:1 planning, implementation, or operations	The reviewed studies do not include activities that impact student outcomes
There is sufficient evidence in written review to judge the above screening criteria	There is not sufficient data in written review to judge the above screening criteria

separate categories for each set of articles in different categories of the identification, screening and selection process. As a result of the screening, 69 review documents were not advanced beyond this stage (marked [1] in References) and 33 review documents were identified as potential candidates for inclusion in the meta-synthesis. The 33 included documents met all eight screening criteria.

Assessing Screened Reviews for Quality

Before proceeding with the meta-synthesis, the 33 research reviews that passed the screening criteria were subjected to an assessment of the qualities of systematic reviews. Table 2 shows the quality assessment criteria used to evaluate each of the 33 screened research reviews. References marked [2] show the 24 research reviews that met the screening criteria but did not meet the quality criteria, receiving a negative score as described in Table 2, for a "systematic" review that could be replicated. Of the remaining nine research reviews receiving a score of 5-8, five went beyond the focus on 1:1 technology initiatives and included broader considerations of technology applications and their impact in K-12 education (marked [3]). The four remaining research reviews, denoted by [4], met the criteria of a "systematic review" and focused on 1:1 technology initiatives.

The four systematic research reviews focused on 1:1 technology included 156 study reports, involving 131 unique project reports. The references denoted [5] identifies these 131 study reports and indicates the reports included in each of the four systematic research reviews ([5-1a, 5-1b, 5-2, 5-3]).

In our search for relevant research reviews, we uncovered several project reports primarily related to updated research on major state or local 1:1 technology initiatives in K-12 education. References marked [6]indicate the 20 additional and recently published reports, primarily from 2009 to 2011, not duplicated by our other literature sources.

Coding Processes

Coding procedures were developed after initial reading and cursory discussion of several articles. The included reviews and research reports were coded according to coding instructions for each of the three analyzed sets of resources (four focused systematic reviews, five systematic reviews of educational technology beyond 1:1 initiatives, and 24 non-systematic practical reviews.). Among the five members of the research team, at least two researchers independently coded each of these three sets of sources to lessen the chance of bias or error. After independent coding, discussion was used to reach consensus and assure accuracy where necessary.

A brief summary of the variables coded across these four coding protocols is found in Figure 4. These variables focused on describing:

- the references of studies found in the four focused, systematic reviews;
- the major research questions;
- methods (procedures, participants, and measures);
- findings; and,
- limitations or strength of evidence for findings in all the reviews discussed.

Table 2. Quality Assessment Criteria for Selection of Research Reviews Included In Meta-Analysis[1]

Question	**Rating[2]**
Did the review ask a clearly focused question regarding 1:1 initiatives and their impact?	
Did the review include confirmation that the screening criteria were met for the included studies?	
Did the review try to identify all relevant studies using available databases and other sources?	
Did the review assess the quality of each study included in the analysis and reporting of results?	
Was a rationale provided for the quantitative and/or qualitative analyses applied to review evidence?	
Were the results and limitations from the analyses clearly presented with regard to major findings?	
Were all of the important outcomes and activities treated in the analysis considered in the findings?	
Were implications or conclusions drawn for policy and/or practice as a result of review findings?	
TOTAL	

[1]Adapted from "10 Questions to Help Make Sense of Reviews" by the Public Health Resource Unit, England (2006) and framed within the general research question guiding the meta-synthesis.
[2]Ratings are as follows: +1=Yes; 0=Can't Tell; -1=No.

Figure 4. Coding for 1:1 Reviews

I. Classifying References
1. Number of references (see Table 4)
2. Reference type (See Table 3)
3. Country of studies from references (See Table 4)
4. Unique and duplication of references (See Table 5)
5. Year of references (Table 6)

II. Describing the Questions Guiding the Reviews
1. Classifying according to the three topics (1=outcomes, 2=implementation, 3=cost)
2. Identifying parts of three topics not addressed (e.g., graduation rate, funding sources)
3. Describing in narrative form generalizations about the questions

III. Methods of Reviews
1. What Procedures were used?
2. Who are the Participants (e.g., grade level, educator characteristic)?
3. What types of Measures used (e.g., standardized tests, survey)?

IV. Findings
1. What was found about outcomes?
    a. Answers to the questions
    b. Strength of findings
2. What was found about implementation?
    a. Answers to the questions
    b. Strength of findings
3. What was found about funding and cost considerations?
    a. Answers to the questions
    b. Strength of findings

While initially coded, information on the questions and methods of the systematic reviews beyond 1:1 technology and the "practical" non-systematic reviews was not included in this report due to a lack of consistently available information and its limited utility in understanding the existing science, specifically on 1:1 technology research initiatives. Coded information on findings from these two sub-groups is included, as well an estimate of the strength of the findings based on available methods information. The four-point code for assessment of strength of findings was as follows:

> 1 = *possible* (evidence is based on self-reported experiences and personal information rather than objective and systematic procedures);
> 2 = *weakly supported* (evidence is based on objective evidence but without clearly defined systematic procedures or with severe methodological limitations for generalizability);
> 3 = *moderately supported* (evidence is based on clearly defined systematic procedures but with a range of methodological strengths and limitations for generalizability);
> 4 = *strongly supported* (evidence is based on clearly defined systematic procedures and, for the most part, methodological strengths for generalizability).

Scores of "3" or "4" came almost exclusively from the group of four focused reviews.

Results

Description of References in the Systematic, Focused Reviews

In the four systematic reviews focused on 1:1 technology, there were 156 total cited references, 131 of which were non-duplicated among the four reviews. A summary of the 156 total reports of 1:1 technology studies is shown in Table 3 by type of research report. The types of references show that the literature has matured in the past 17 years. The Penuel et al. (2002) review only contained one journal article but subsequent reviews showed consistent increases in absolute numbers of published journal articles. Nevertheless, when looked at in total, 57% of the 156 were project reports (typically, small-scale evaluation studies), suggesting that the focused systematic review articles in 1:1 educational technology were primarily based on research that could not be characterized as peer reviewed in the traditional use of the term. Table 4 identifies the 156 references by breakdown of school-based studies in the US vs. in other countries. It shows a fairly consistent pattern that research being synthesized in the past decade was generally, but not exclusively, conducted in the United States. Table 5 reports references that are common to two or more of the four research reviews so that authors can see the degree of overlap. The overlap of the references between reviews is small (25/156 or 16%), well beneath the threshold of 25% used in other meta-syntheses (Tamim et al., 2011) to remove a synthesis from consideration within a meta-synthesis approach. Table 6 shows the year of publication or posting of the research reports in these different categories. About 8% of the total number of items we included in this meta-synthesis (n=253) were published or posted in the 1990s, compared to 32% in the period 2000-2004, 33% in the period 2005-2009, and 27% in 2010 or 2011.The information in these tables and the reference list shows that recent literature included in this meta-synthesis consists of more journal articles, again suggesting increasing maturity to this literature.

Table 3. Type, Number, and Percent[1] of References Cited in Four Systematic Reviews of Research Included in Meta-Synthesis

Reference Type	Penuel, et al. (2002)	Penuel (2005)	Bethel, et al. (2008)	Fleisher (2011)	Total	Percent of Total
Project Report	10 (53%)	16 (53%)	63 (71%)	0 (0%)	89	57%
Journal Article	1 (5%)	7 (23%)	12 (13%)	18 (100%)	38	24%
Conference Paper	5 (26%)	5 (17%)	4 (4%)	0 (0%)	14	9%
Dissertation	3 (16%)	1 (3%)	1 (1%)	0 (0%)	5	3%
Unpublished Paper	0 (0%)	0 (0%)	4 (4%)	0 (0%)	4	3%
Book	0 (0%)	1 (3%)	1 (1%)	0 (0%)	2	1%
Other[2]	0 (0%)	0 (0%)	4 (4%)	0 (0%)	4	2%
Total	19 (100%)	30 (100%)	89 (100%)	18 (100%)	156	100%

[1]Percent rounded to nearest whole percent.
[2]Other includes ERIC Digest article (1), blog article (1), and occasional paper (2).

Table 4. References from US Studies and Studies in Other Countries Cited in Four Systematic Reviews of Research Included in Meta-Synthesis

Systematic Review	Number of References	References of US Studies	References of Studies from Other Counties	Percent US References
Penuel, et al. (2002)	19	19	0	100%
Penuel (2005)	30	26	4	87%
Bethel, et al. (2008)	89	77	12	87%
Fleischer (2011)	18	16	2	89%
Total	156	138	18	88%

Table 5. Unique and Duplicate References Cited in Four Systematic Reviews of Research Included in Meta-Synthesis

Systematic Review	Total References	References Common to Penuel et al. (2002)	References Common to Penuel (2005)	References Common to Bethel et al. (2008)	References Common to Fleischer (2011)	Total Unique References
Penuel, et al. (2002)	19	X	X	X	X	X
Penuel (2005)	30	2	X	X	X	X
Bethel, et al. (2008)	89	4	15	X	X	X
Fleischer (2011)	18	0	1	3	X	X
Total	156	6	16	3	X	131

Table 6. Year of Publication or Posting for References Cited in Selected Research Reviews Included in Meta-Synthesis

Groups of References	*<2000*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*Total*
Reviews Excluded from Meta-Synthesis[1]	1	0	0	1	2	5	2	3	4	7	10	22	11	68
Non-Systematic "Practical" Reviews	0	0	0	1	1	0	1	1	3	1	4	8	4	24
Systematic Reviews that Went Beyond 1:1	0	0	1	0	1	0	0	0	1	0	1	0	2	6
Systematic Reviews Focused on 1:1	0	0	0	1	0	0	1	0	0	1	0	0	1	4
Non-Duplicate References from Focused Reviews[2]	19	9	11	6	16	23	19	11	8	5	2	2	0	131
Updated Reports of Major 1:1 Initiatives	0	0	0	0	0	0	0	0	0	0	1	11	8	20
Total	20	9	12	9	20	28	23	15	16	14	18	43	26	253
Percent	8%	4%	5%	4%	8%	11%	9%	6%	6%	6%	8%	17%	10%	100%

[1]Pre-2000: 1999 (1)
[2]Pre-2000: 1992 (1); 1994 (1); 1995 (1); 1996 (2); 1997 (2); 1998 (6); 1999 (6)

Description of Other References Reviewed in this Meta-Synthesis

While this review emphasizes identification and analysis of systematic reviews focused on 1:1 educational technology research, it aims to provide a more thorough review of the literature through identification (e.g., excluded reviews) or identification and description of two other bodies of literature: systematic reviews of educational technology beyond 1:1 initiatives and non-systematic "practical" research reviews. This broad perspective is necessary to (1) give a comprehensive view of the state of the art in 1:1 educational technology research, (2) address broad questions related to student outcomes, implementation concerns, and funding issues that are not fully answerable from focused systematic reviews, and (3) reflect considerations for recency effect of findings and implications for future research.

Methods of Focused Systematic Reviews of 1:1 Technology

The four focused systematic reviews were selected because they contained all eight characteristics of quality and were focused on 1:1 technologies. However, they took different approaches and with different emphases within their research questions and procedures, yielding different confidence and applicability of the findings of the reviews to the current state of the art. The authors of the current meta-synthesis utilized the Methodological Quality Index created by Tamim et al. (2011, p. 12-13) in their meta-synthesis of educational technology research to assess the quality of methods beyond the quality criteria used for inclusion. Three of the four studies scored in the Moderate Quality range on Tamim's Index. The fourth, Bethel et al. (2008) scored in the High Quality range, suggesting that findings from this review represent a more rigorous process and one can have more confidence in its validity. Participants in the four focused, systematic reviews involved grades K-12 and included information from both student and teacher measures with higher rigor usually representing data from student achievement than implementation or funding issues.

The Penuel et al. (2002) review synthesized information from studies conducted between 1995 and 2001 with about one-half (9/19) coming from 1998 and 1999. Of these 19 studies, two involved randomization and controls, 10 involved matched quasi-experimental designs, and only one was published in a peer reviewed journal. Therefore, this review shows that the initial literature on 1:1 technology was sparse and generally without significant rigor. More importantly, the culture of ubiquitous computing, maturation of the Internet, and the quality of computer devices and their wireless capacity was dramatically different over a decade ago than is available for consideration by districts for 2012 and beyond. Nevertheless, early research on 1:1 technologies show some similarities in trends reported in later research, lending support for certain conclusions explored below.

Penuel (2005), also re-published as a journal article in 2006, conducted a second review of studies published largely between 2002 and 2004. Of the 30 studies included in this review, only one was a randomized experiment and only two used high quality quasi-experimental designs, again conveying that research was very limited by its quality and

replication into the mid 2000's. While the Internet was well established between 2001 and 2005, computer devices and usage were significantly different than exists in 2012. For example, the iPhone and/or Android phones had two more years to be released and iPad five more years. Nevertheless, similar to the first five years of research in 1:1 educational technology, information from this second five-year time period does provide some additional, potentially useful information, particularly regarding implementation and how such initiatives effect the learning environment and home-school connection, frequent foci of the studies in this review, as will be explored below.

All but two of the reports included in Bethel et al. (2008) systematic review were from the years 2000-2007. This review was more comprehensive in its time inclusion criteria and identification methods of relevant studies than the previous two. It also represents a higher quality of review by using more powerful inferential statistics. Bethel et al. (2008) utilized mature meta-analytic techniques for synthesizing information on student achievement outcomes from 22 studies and 18 independent effect sizes of 1:1 technology initiatives, but only vote counting and percentage of perceived gains for the 65 that reported data on student and teacher perceptions from survey data. Likewise, they also included information from six additional reviews (mostly non-systematic narrative style reviews) to convey a further picture of the literature.

Fleischer (2011) used a systematic qualitative approach to analyze 18 peer-reviewed studies published between 2005 and 2010. His review was focused on the phenomenology of the individual and personal use of computers in learning settings using 1:1 initiatives studied by empirical means. The included studies focused most commonly on instructional methods or learning strategies and none focused on knowledge formation or the effects of implementing 1:1 technology on classroom communication, bullying, or the psychosocial environment. There were two main themes explored, those with pupil-related effects such as amount and type of usage, experiences of and problems with learning, and test scores, and those with teacher-related results, such as changes in professional culture, teacher concerns about implementation, curriculum issues, professional development programs and the socioeconomics of the surrounding society.

Methods of Non-systematic Reviews

The twenty-four reviews identified as non-systematic were coded according to the strength of findings using the one to four rating system described earlier in this report. Some areas could not be coded due to a lack of information. In all instances the results that could be coded received a one or two rating due to a lack of clearly defined systematic procedures or limited methodological descriptive information. Measures may have been identified in broad terms such as survey or interview but instruments employed were not described in details. Generally, participants were not identified specifically by grade level sand sample size information was not included. Given the limitations mentioned, practical information for educators/districts engaged in or interested in pursuing a 1:1 technology initiative were noted and have been included in this report.

The group of 24 non-systematic reviews provides practical information, especially focused on operational items that concern planning, implementation and funding. Issues

related to professional development and leadership were the most frequently discussed. The discussion of findings also draws from this subset of the literature. However, the lack of systematization in the processes the reviews followed and the lack of specificity of the research they cited brings significant caution in the interpretation of the findings.

Methods and Findings from Systematic Reviews beyond 1:1 Technology

The screening, quality, and focus parts of the selection process identified a group of five systematic reviews that were inclusive of but beyond 1:1 initiatives. These reviews used a variety of methodologies, often sophisticated, but provided almost no unique information to address what is known about the three research questions—outcomes, implementation and funding— beyond that more specifically obtainable from the four systematic reviews that focused on 1:1 initiatives and the group of 24 non-systematic practical reviews. However, it did supply some potential intervening variables (or mediators) that might explain under what conditions 1:1 initiatives would be more likely to succeed.

First, several reviews mentioned that effective implementations of educational technology occur when they are part of ongoing reform and not the sole reform. One-to-one technology should be deliberately integrated with other changes to the curriculum and/or teaching strategies (i.e., pedagogical innovation) so that it is not a stand-alone feature of the learning environment.

The meta-analysis by Lou, Abrami & d'Apollonia (2001) provides information on how educational technology is affected by group vs. individualized work with computers. The amount of the task attempted, task completion time, use of a variety of learning strategies and attitude towards working in small groups were generally better fostered with tutorials and feedback than when students were asked to work individually or with less feedback. While more specific, this offers further support that educational technology should be used within a context supported by teachers, preferable than as a direct instruction mechanism. Likewise use of specific cooperative learning strategies and heterogeneity in grouping improves performance when requiring small group with computers, similar to findings related to group work without computers. Also, it appears that lower ability students benefit in terms of the amount of time they will spend on task from group work with educational technology more than medium or high ability students who perform more similarly (or better in the case of medium level students only) whether working individually or in groups with computers. Male students appeared to need more time to complete tasks with educational technology when working in groups rather than alone. This finding may not be unique to 1:1 learning environments but rather reflective of small group work more generally.

It appears that educational technology is more successful when used regularly, not just once a week. It is not clear, however, if there is a detectable threshold for 1:1 technology use by curriculum area. For example, the meta-analysis by Cheung and Slavin (2011) compared mathematics-related uses of technology for less than 30 minutes per week with more than 30 minutes per week, which is a relatively low level of increase in usage rather than a true "ubiquitous" computing model. We need more and better designed studied to

address the threshold issue. Next, it appears that in science and math subjects, educational technology is associated with a greater number of learning strategies attempted and attitude towards working in small groups with computers. Finally, the reviews report that there has been very limited research on handheld devices (tablets or smartphones not laptops or desktops), particularly from US based studies, suggesting that less is known about whether the research on educational technology or 1:1 initiatives specifically would generalize smoothly with these smaller, more portable, more personalized devices or offer smaller, larger, or different effects.

Systematic vs. Non-systematic Addressing of the Three Research Questions

As shown in Figure 2 (page 7), the 15 research questions identified from OERI project committees and superintendents were grouped into three broad topics: student outcomes, professional development and implementation, and funding. Each area was addressed to different extents by the groups of systematic or non-systematic reviews.

Several areas of *student outcomes* (e.g., writing and math achievement) have been addressed in systematic reviews, including meta-analyses. Our meta-review used procedures and criteria common to other systematic reviews of research to address outcomes-related questions. However, some student outcomes have been addressed only in non-systematic reviews (e.g., 21st Century skills) or individual studies (e.g., graduation rate). Non-systematic reviews were drawn on to provide practical evidence for the meta-review in these areas.

Regarding *professional development and implementation*, we found limited evidence from systematic reviews, but significant discussion in non-systematic reviews and some examples from individual reports. We concluded that more attention to local practices in original research and systematic reviews can help advance understanding of implementation factors such as leadership and cultural change in 1:1 initiatives.

For *funding* and related financial costs, we found almost no comparable evidence in systematic reviews, and limited information from non-systematic reviews or individual studies, to draw valid conclusions. As discussed below, without more systematic attention to the costs of 1:1 technology initiatives and the relationships of costs to outcomes, the over-arching question of cost-benefit cannot be answered.

Findings for the Three Research Topics

The first research topic concerned **student outcomes**, including writing and non-writing achievement, 21st century skills, engagement or motivation, and technology usage and literacy. Student outcomes were investigated through quantitative means of direct assessment of student performance as well as teacher perceptions of student performance. Improved *writing* is the most consistently supported beneficial achievement outcome of 1:1 educational technology initiatives. The effect is small to medium, approximately g = .30-.35, which indicates there is evidence across multiple studies with sufficient confidence that the effect is greater than zero. Outcomes in other achievement areas show

inconsistent or minimal benefits. Bethel et al. (2008) found an effect size of g = .01 for non-writing achievement. Specific findings on *math* and *reading* appear to be negligible or have mixed findings. Research into the effects of 1:1 computing have been too limited with regards to *science* or *social studies* achievement to draw conclusions.

One-to-one technology initiatives often have goals for student outcomes beyond traditional achievement. These are sometimes called *21st Century skills*, such as the ability to work independently, be critical in consuming information, completing larger or more complex projects, and working collaboratively and expansively with peers and the home and surrounding communities. Research in these areas is characterized by less clarity, rigor and consistency of findings. Nevertheless, some information can be characterized as weakly or moderately supported. For example, it is probable that students' collaboration with teachers, other students, and/or people in the community will be improved through 1:1 initiatives, as this finding has been shown in several studies. It also is probable that students will conduct more research, maintain attention on longer term projects, know more available resources for consultation, and improve their organizational skills as a few studies have supported these outcomes.

For *engagement and motivation*, 1:1 technology seems to have positive effects. There are multiple studies and reviews that show improved student engagement and motivation, but these studies often refer to disparate outcomes labeled engagement or motivation and/or have not been adequately synthesized within the literature to be considered strongly supported. Overall, there is moderate support for 1:1 technology initiatives contributing to enhanced engagement and motivation. There are suggestions in the research reviews that 1:1 technology initiatives improve students' attitudes toward technology, subject matter, parent involvement and communication, and teacher-student relationships. More and better designed research also is needed to address attitude questions.

A finding in at least one systematic review, and a consistent pattern across non-systematic reviews, is that student engagement is improved when 1:1 technology is supplemental to systematic improvements in the teaching and learning environment rather than as a stand-alone initiative.

Technology use and literacy is another major category of student outcomes that have been researched. The existing research strongly supports the conclusion that technology use increases when 1:1 initiatives are enacted. Likewise, evidence across reviews in this meta-synthesis strongly supports the finding that 1:1 initiatives improve student computer literacy. While these findings are consistent across studies, nevertheless the findings in these areas have not been synthesized in such a way to identify a consistent magnitude of effect. In other words, the range has been small to large in how much more students will use or be literate with computers. There also are findings from the non-systematic reviews that suggest the importance of engaging parents in order to realize higher-quality student usage, particularly the use of 1:1 technology to enhance student exploration and self-expression.

The second topic concerned **professional development and implementation concerns**. Based on the evidence reviewed in our meta-analysis, it is probable that *professional development* will be more successful if it addresses teacher beliefs about instruction and technology, includes relevant hands-on training, supports teachers as reflective practitioners, involves collaborative or cooperative learning among teachers, and is accompanied by sufficient technical support and collegial assistance when needed. These findings are strikingly similar to the general findings for professional development reported by Darling, et al. (2010). Within 1:1 professional development, a particular focus is toward teachers' beliefs and practices supporting learner-centered and individualized instruction. Learner-centered instruction refers to trusting and empathizing with students, having high expectations, believing teachers are more facilitators than direct imparters of information, fostering collaboration as well as individual initiative, and supporting differentiated and self-directed student learning (Cornelius-White & Harbaugh, 2010). Both of these references are supported by multiple studies. There were an insufficient number of studies to reach conclusions about the following issues related to professional development: teachers' computer literacy and usage prior to initiating 1:1 initiatives; whether face-to-face or virtual forms of 1:1 professional development are more effective for particular objectives and participants; whether professional development is more effective if it focuses on the personal concerns of teachers regarding using computers and/or teaching strategies to be employed; how and when to provide the instructional design and development help teachers might need in approaching a given curriculum with 1:1 technology; and under which conditions it is more effective to use local or contracted personnel for extended training or mentoring groups to continue professional development after initiating a 1:1 plan.

With regard to *leadership*, it appears probable that leaders will be more successful if they are deliberate in their change management strategies by actively listening, adjusting, and building consensus with educators, parents, and community members before and during implementation of a 1:1 initiative. There is also evidence that effective leaders in 1:1 initiatives address access inequities across schools and students, build community consensus, plan for and allocate sufficient funding for needed 1:1 resources and support, and consider the need for teacher assistance by students or teacher volunteers, internal technical staff, and support from external technical support rather than relying on only one of these sources.

Another area of implementation concerns *teaching strategies*. It is probable that a focus on learner-centered educational ideas and methods will improve implementation as several studies report that as a part of or outcome from successful professional development in 1:1 initiatives. There also is moderate support across systematic research reviews that effective 1:1 programs tend to include less large group instruction, more project-based, inquiry, or cooperative learning strategies, and ongoing communications and orientations for parents and students.

The third topic concerned **funding issues**, especially regarding digital content instead of textbooks or written materials, deployment costs, and sources of funding. Almost no information is available from focused systematic reviews to address many of these

funding issues. However, information from other sources identified in the meta-synthesis does provide some possibly helpful or empirically supported advice. The information is typically qualitative and descriptive, reporting information but not linking that information clearly to implementation or outcome processes directly.

For example, some districts have reported declines in textbook costs when utilizing free or lower cost digital content, often reporting reductions near 50-80%, which in actual dollar amounts totaled $40 - $60 per student. Likewise critics have said that size, weight, and flexibility of textbooks create indirect economic benefits in terms of health, quickness to respond to lost materials, and staying current. Reduction in traditional seat time through use of blended formats utilizing virtual, online work can result in significant decreases in costs (Wilson & Gielniak, 2011). Examples of specific costs are either hard to come by or of limited utility.

The approximate costs of initiating 1:1 technology projects is particularly difficult to estimate as districts begin in different places with their infrastructure, make significantly different decisions in training and hardware expenditures, and source funding. Some considerations include budgeting for hardware, software, training, tech support, data storage, servers or cloud service, and insurance.

It is probable that effective 1:1 programs use multiple funding sources. These funding sources might include, for example, local tax levies; reallocation from saved resources through replacement costs (e.g., reduction in textbook expenditures, professional development budget directed to 1:1 training, business processes through email rather than post or photocopy, electronic record keeping, etc.); per student fees and/or supplemental for funding students who cannot or do not pay fees; state and federal grant and technology support funds; and corporate and foundation grants. To secure funding or in-kind support from multiple sources such as these, school district could: argue that improved outcomes will mean more tax revenues in the future through a higher educated, more advanced workforce; implement parent/care giver and bring your own device programs; form consortia with other districts and one or more universities for cooperative purchasing power; form partnerships with business and community organizations for financial and in-kind contributions; combine funds from separate curriculum budgets or organizational units; and attempt creative fund raising such as through service-learning or marketing that influences students, their families or community non-profits and businesses.

Strength of Findings for the Three Research Topics

The four systematic reviews provide the highest quality information available, but focus largely on student outcomes, secondarily on planning and implementation concerns and almost none on funding. Some outcomes, such as achievement and technology use and literacy has been sufficiently studied and with sufficient rigor to draw clear conclusions, while other areas have not been covered as well, but conclusions can be drawn with some confidence. The lack of coverage of some areas of implementation, and particularly funding issues leads to greater utility for the lower scientific quality group of non-systematic reviews.

The group of 24 non-systematic reviews provides practical information, especially focused on operational items as concerns planning, implementation and funding. Issues related to professional development and leadership were the most frequently discussed. The discussion in these areas below providing specific findings draws heavily from this subset of the literature. However, the lack of systematization in the processes the reviews followed and the lack of specificity of the research they cited brings significant caution in the interpretation of the findings.

Table 7 summarizes the strength of evidence for findings from the systematic reviews and non-systematic reviews used in this meta-synthesis. In addition, Table 7 includes the major findings from a large-scale survey administered and reported by Project RED (Revolutionizing Education).

This Project RED survey, administered between September 2009 and May 2010, was sponsored by Intel and four other industry-related organizations (Apple, Pearson Foundation, Qwest Communications, and eChalk). The three goals of the survey that were tested as hypotheses by Project RED were: (1) properly implemented educational technology can substantially improve student achievement; (2) properly implemented educational technology can be revenue-positive at all levels—federal, state, and local; and (3) continuous access to a computing device for every student leads to increased academic achievement and financial benefits, especially when technology is properly implemented (Greaves, et al. 20010b, p. 2). The survey was completed by a non-random, self-selected sample of 936 invited public school respondents (about three-fourths of whom were principals or school-level technology coordinators), representing 768 public elementary, middle, and high schools, as well as a combined category (K-12). While conclusions the authors drew from survey findings were stated as generalizations for K-12 public schools in supporting the three project goals ("hypotheses tested"), the authors noted in their Appendix B (Research Methods and Data Analysis) the following challenges or potential limitations of their research (Greaves, et al. 20010b, p. 149):

- "It could be argued that self-reported data on outcomes, such as test-score improvement, dropout rate reduction, and course completion, is self-serving and that respondents to a survey on 'technology-transformed schools' might be biased in favor of reporting strong outcomes."
- "It also could be argued that this respondent data set is self-selected and therefore not representative of all schools."
- "Several [survey] questions have multiple variables imbedded."
- "We originally intended to study technology-rich school environments . . . however our respondents are more diverse. . . . we will reword some of the survey questions and potential responses to account for schools without robust technology implementations."
- "Ideally, we need to find ways to verify self-reported data."
- "Although our total population [sample] is reasonably large, the population [sample] within each subgroup was too small to validate many serendipitous findings."

Table 7. Evidence and strength of findings by research domain for impact of 1:1 technology initiatives

	Systematic (S) Reviews	Non-Systematic (NS) Reviews	Project RED	Strength of Findings[1]
Student Outcomes	Using standardized tests, effect size for writing small to medium (*g* = .31-.35) and negligible to small (*g* = .01-10) for other academic areas assessed through standardized tests.	Survey information shows that teachers often believe 1:1 improves student achievement, especially in the area of writing. Higher graduation rates and increased enrollment in upper level and dual enrollment courses also mentioned.	Properly implemented 1:1 technology results in higher test scores and higher rates of course completion, dual enrollment, graduation, and college attendance.	S Reviews (4) NS Reviews (1) Project RED (1)
	Student development of research, organization, and resourceful skills weakly supported; development of collaboration skills moderately supported.	Students are better organized and more skilled at research.	Not addressed	S Reviews (2-3) NS Reviews (2) Project RED (1)
	Improved student attitudes towards technology, teacher-student relationships, and parent communication moderately supported.	Increased level of student engagement and student motivated to do better quality work. Students edit their work more frequently.	Properly implemented 1:1 technology results in fewer disciplinary actions and lower dropout rates.	S Reviews (3) NS Reviews (2) Project RED (1)
	Greater technology usage and literacy strongly supported but without a reliable estimate of the size of the effect.	Students appear to use computers for a greater variety of purposes and these purposes appear to involve higher order thinking or initiative.	Properly implemented 1:1 technology results in student daily use of technology for online collaboration and search engines.	S Reviews (4) NS Reviews (2) Project RED (1)
Professional Development and Implementation	Professional development involving teacher beliefs and concerns, hands-on training, and technical support that results in more learner-centered practices is weakly to moderately supported.	Professional development is critical to the success of 1 to 1 initiatives. Professional learning should include technology skills that are anchored in the specific contexts of teaching and learning, and aligned with curriculum and standards.	In properly implemented 1:1 technology initiatives leaders provide time for teacher professional learning and collaboration at least monthly.	S Reviews (2-3) NS Reviews (2) Project RED (1)
	Leadership that positively impacts teacher and student practices through actions such as community consensus building, providing layered technical support, and monitoring morale is weakly supported. Change management strategies for effective 1:1 implementation are moderately supported.	Leadership is a key component of effective 1:1 initiatives along with having a shared vision that guides the program and is communicated with all stakeholders.	In properly implemented 1:1 technology initiatives principals are trained in change management that includes teacher buy-in, best practices, and technology-transformed learning.	S Reviews (2-3) NS Reviews (2) Project RED (1)
	That learner-centered teaching will improve 1:1 implementation and/or be a result of 1:1 implementation is moderately supported.	Less large group instruction and more inquiry and cooperative strategies tend to be employed with 1:1 technology initiatives.	In properly implemented 1:1 technology initiatives technology is integrated into every intervention class (ELL, Title I, special education, etc.); online assessments are done at least weekly.	S Reviews (3) NS Reviews (1-2) Project RED (1)
Funding	That multiple sources of funding will be required to sustain and upgrade 1:1 initiatives is weakly to moderately supported.	The need for ongoing research and evaluation of 1:1 initiatives, including but not limited to cost-benefit analyses and return on investment (ROI) in relation to current practices and other educational innovations, is strongly advocated.	Regarding costs and saving, properly implemented 1:1 technology initiatives result in less paperwork, lower paper and copying expenses, higher teacher attendance, and improved student outcomes; estimate annual ROI is $459 per student or $25B nationally.	S Reviews (2-3) NS Reviews (2) Project RED (1)

[1]Strength of findings for a particular research domain refers to the quality of supporting evidence, based on following rating system: 1 = *possible* (evidence is based on self-reported experiences and personal information rather than objective and systematic procedures); 2 = *weakly supported* (evidence is based on objective evidence but without clearly defined systematic procedures or with severe methodological limitations for generalizability); 3 = *moderately supported* (evidence is based on clearly defined systematic procedures but with a range of methodological strengths and limitations for generalizability); and 4 = *strongly supported* (evidence is based on clearly defined systematic procedures and, for the most part, methodological strengths for generalizability).

With these limitations in mind, particularly the population/sample problem and the self-reporting of perceptions problem without verification of instrument reliability, we rated the evidence from the Project RED survey (Greaves, et al., 2010b) as possible (not probable), that is, based on self-reported experiences and personal information rather than objective and systematic procedures. While advocates of 1:1 technology initiatives desire strong supporting evidence for effective practices that have a positive impact on student learning, other student outcomes, and cost-benefit returns, Project RED survey results thus far are exploratory and suggestive rather than explanatory and conclusive.

Discussion

Succinct Responses to 15 OERI Questions of Interest

A. Business and Community Partnerships Committee

1. Does the proper use of "1:1 technology" improve student learning in the basics (i.e. reading, writing, and math)? *We found strong evidence that 1:1 technology has improved student writing achievement. However, we did not find supporting evidence for the other areas of student achievement outcomes.*

2. What "1:1 technology" for students is the best to use if one wishes to improve student achievement for all student groups? *Because we did not find supporting evidence of the positive impact of 1:1 technology on student achievement test scores, we could not identify any devices (hardware and software/applications) for the improvement of student achievement.*

3. What steps (e.g., PD) does a district need to take in order to properly implement "1:1 technology" to the point school districts get a return on their investment (improved academics)? *We think the research framework emerging from our meta-synthesis (shown in Figure 6) identifies the key factors and variables that impact return on investment. Professional development, particularly as it impacts teaching and instruction, pedagogical innovation, the interpretation of curriculum goals and objectives, and assessment practices, is one of those factors. Attention to leadership, school culture, infrastructure and support, district and state policies, school-parent-community-business partnerships, the devices used (hardware and applications), costs, and funding also are other key implementation concerns. It is important to note that, for the most part, the OERI project sub-committee topics address this range of concerns. Significant topics omitted from the initial set of project sub-committees include implementation plans, the process and outcomes of goal setting and vision sharing, and research and evaluation (including but not limited to cost-benefit and return on investment studies).*

B. Funding and Budgeting Committee

1. Is the 1:1 initiative more effective and efficient than the use of textbooks and other materials? *We did not find any reviews that compared 1:1 to the use of textbooks or other materials, probably because it is not so much the form of the material but rather how it is used in teaching and learning that makes the difference in 1:1 initiatives.*

2. What process will work best to fund the deployment of the 1:1 initiative? *There is not much detail in the research reviews we analyzed regarding cost or funding mechanics. We did find support for the probability that effective 1:1 programs use multiple funding sources. These funding sources might include, for example, local tax levies; reallocation from saved resources through replacement costs (e.g., reduction in textbook expenditures, professional development budget directed to 1:1 training, business processes through email rather than post or photocopy, electronic record keeping, etc.); per student fees and/or supplemental for funding students who cannot or do not pay fees; state and federal grant and technology support funds; and corporate and foundation grants. To secure funding or in-kind support from multiple sources such as these, school district could: argue that improved outcomes will mean more tax revenues in the future through a higher educated, more advanced workforce; implement parent/care giver and bring your own device programs; form consortia with other districts and one or more universities; form business partnerships; combine funds from separate curriculum budgets or organizational units; and attempt creative fund raising such as through service-learning or marketing procedures that influence students, their families or community non-profits and businesses.*

3. What are the training and deployment costs for an effective 1:1 initiative? *Again, we did not find many details in our research reviews about costs of 1:1 technology initiatives. However, several different types of costs might be considered—e.g., one-time and continuing costs, direct and indirect costs, incremental and marginal costs, monetary and non-monetary costs, implicit and explicit opportunity costs. There are three other important considerations about costs for training and other implementation concerns. One is the value of resources necessary to achieve a particular objective or outcome at a particular scale. A second is the potential of shifting costs (or savings) from a non-1:1 activity to a 1:1 activity. A third consideration is cost and outcome measures that are used, and whether it is feasible to assess the cost-benefit or ROI from the data collected with the measures that are used. The Total Cost of Ownership (TCO) and Value of Investment (VOI) tools available from the Consortium for School Networking (CoSN,* http://www.cosn.org/*) are valuable resources to address these concerns.*

C. Instruction and Professional Development Committee

1. What are the best research-based practices to implement and sustain professional development by utilizing technology that is developmentally appropriate for grades Pre-K through postsecondary education? *We found in our meta-synthesis support that professional development will be more successful if it addresses teacher beliefs about instruction and technology, includes relevant hands-on training, involves collaborative or cooperative learning among teachers, and is accompanied by sufficient technical support and collegial assistance when needed. We also found that, through effective professional development, teachers' beliefs tend to change towards those that might be considered more learner-centered. Learner-centered instruction refers to trusting and empathizing with students, having high expectations, believing teachers are more facilitators rather than direct imparters of information, fostering collaboration more than individual work, supporting differentiated (developmentally appropriate) and self-directed student learning (Cornelius-White & Harbaugh, 2010). Both of these findings are supported by multiple studies. There were an insufficient number of studies to reach conclusions about the following issues related to professional development: teachers' computer literacy and usage prior to initiating 1:1 initiatives; whether professional development is more effective if it focuses on the personal concerns of teachers regarding using computers and/or teaching strategies to be employed; how and when to provide the instructional design and development help teachers might need in approaching a given curriculum with 1:1 technology; and under which conditions it is more effective to use local or contracted personnel for extended training or mentoring groups to continue professional development after initiating a 1:1 plan.*

2. What instructional technology tools are being used effectively by districts that are currently engaged in 1 to 1 technology? *We did not find any research reviews that provided supporting evidence of specific technology tools (e.g., 1:1 devices) found to be more or less effective in 1:1 technology programs. Rather, the emphasis in reviews we analyzed was the importance of using technology in learning-centered practices that, in turn, are linked to intended outcomes. In other words, "put the pedagogy before the device." (Alex Inman, personal communication, 4-23-2012)*

3. How do we integrate effective use of technology with best practices for maximizing student achievement? *In addition to the cost-benefit (or ROI) issue, this is the most important question for 1:1 technology initiatives. Our best shot at responding to this question is found in Figure 6, which maps the domain of research for factors and variables that link technology, "best practices," and student outcomes. Based on our meta-analysis, there is no simple answer to this question but rather an approach (or framework) for building answers over time.*

D. Individual OERI Superintendent Questions

1. Where is the evidence of increased academic achievement for students who participate in 1:1 programs? *The Project RED survey, based on the self-reported perceptions of a self-selected sample of principals, school-level technology coordinators, and other school personnel, offers some "soft" data as evidence for increased academic achievement (i.e., perceptions of increased test scores). The strongest evidence we found for the link between 1:1 technology and student achievement was for writing. We also found some relatively weak to moderately strong evidence supporting student development of 21st century skills in 1:1 programs. Overall, the claim that 1:1 technology initiatives improve student achievement, especially as measured by standardized state tests such as MAP, is specious.*

2. How do the results of effectiveness of 1 to 1 technology compare with students of similar demographics who are not using 1 to 1 technology? *We did not find supporting evidence in our meta-analysis to answer this question.*

3. What professional development opportunities/activities have been identified as the most successful to assist teachers as they begin the 1:1 process? And how was the PD implemented? *From their comprehensive review of research on exemplary professional development programs, Darling-Hammond, Meyerson, LaPointe and Orr (2010) identified the following common components:*

    - *Research-based content, aligned with professional standards and focused on instruction, organizational development, and change management.*
    - *Curricular coherence linking goals, learning activities, and assessments around a set of shared values, beliefs and knowledge about effective organizational practice.*
    - *Field-based internships that enable the application of leadership knowledge and skills under the guidance of an expert practitioner.*
    - *Problem-based learning strategies, such as case methods, action research, and projects that link theory and practice and support reflection.*
    - *Cohort structures that enable collaboration, teamwork and mutual support.*
    - *Mentoring or coaching that supports modeling, questioning, observations of practice and feedback.*
    - *Collaboration between universities and school districts to create coherence between training and practice as well as pipelines for recruitment, preparation, hiring and induction.*

4. Does research really show that engagement and attendance increases while discipline decreases in schools with 1:1 programs? How about graduation rates? *We found that, compared to the findings from our meta-analysis of 1:1 research reviews, only the authors of the Project RED survey findings (Greaves, et al., 2010b) make the claims about all of these positive outcomes together.*

5. How are concerns for leadership, change, curriculum, and assessment addressed in the research on 1:1 technology initiatives? *For a summary response to this question, see Figure 6 for and its discussion in the text of this report regarding these concerns and suggestions about how they are related and how they impact student outcomes.*

6. What are the main concerns for virtual learning/online learning/blended learning in 1:1 initiatives? *We did not find any systematic research reviews that provided evidence of concerns for virtual or online or blended learning in the context of 1:1 initiatives, or vice versa. This could be an important arena for future research.*

Limitations of This Meta-Review

First, all reviews are limited by the quality and relevance of the studies reviewed. This meta-review is limited by the quality of the 33 earlier reviews of research. Findings from our meta-synthesis were presented with their strength of evidence base as seen through the lenses of the original reviews (See Table 7). This strength of evidence classification demonstrates limitations of conclusions drawn based on the quality of the original claims that the current review synthesizes. We noted topics (e.g., leadership, hardware and infrastructure, and costs) where information was sparse or non-existent within the systematic reviews, resulting in reliance on non-systematic reviews and individual studies to address concerns within these topics.

Second, a meta-review is also limited by the quality of the original studies included in the earlier reviews. Flaws in original research, not just in the research reviews, limit the quality of the conclusions drawn in this meta-review. More specifically, a significant limitation of the current meta-synthesis is that study-level analysis was not conducted on the 131 original studies that were previously synthesized in the four focused systematic reviews beyond information found in Tables 3, 4, 5, and 6. These tables looked at important but essentially non-substantive qualities of the studies, such as identifying overlap of these studies across the reviews, year of publication, country in which research was conducted, and type of research report. The current meta-synthesis did not include an analysis of methods or findings at this study level for the original 131 reports.

Third, while this meta-synthesis aimed to address recency effect, it is still limited by them. Every attempt was made to select reviews and studies as recent as possible in reporting and analyzing the existing literature; however traditional sources (such as journal articles and books) have significant lag in publication time compared to web resources and project reports available in local communities. The group of 20 individual studies, which includes the most recent research reports (mostly from 2010 and 2011) of major state and local 1:1 initiatives, have yet to be thoroughly analyzed as of the April 17, 2012 presentation to the OERI Advisory Council.

Fourth, none of the data sources used in this meta-synthesis focused on 1:1 devices other than laptops. As noted earlier in this report, a wide range of tablets, netbooks, smart phones, and small hand-held devices also could be used in 1:1 technology initiatives.

Also, among laptops today compared to five or ten years ago, there are major differences in computer capability, screen features, usage by students and teachers, wireless and internet technology, pricing, and applications available. 1:1 technologies change rapidly, and significant changes in devices can occur within a 12-month to 18-month time period, which strongly suggests that recency of studies will continue to be a pervasive concern for research and practical implications involving 1:1 technologies.

Fifth, there are limits to the coding scheme utilized. Inter-rater reliabilities were formally checked on the coding of the most objectively coded material (for example information in Tables 3-6). These checks showed high consistency on the initial attempt and perfect consistency upon the second attempt. Likewise, on less "objective" items of the coding process (e.g., extracting specific findings for implementation reported descriptively or from a qualitative design), agreement appeared high, but statistics were not computed. Similar to the second attempt on more "objective" coded elements, agreement between independent coders of qualitative and narrative data was very high when they met together and discussed their codings until consensus was reached or differences in interpretation were accepted. As would be expected, these "subjectively" described or measured elements and their coding were concentrated more highly in the group of 24 non-systematic reviews. These non-systematic reviews were drawn on more heavily to locate findings and draw implications that address questions about student outcomes other than achievement, professional development, implementation, costs, and funding.

Future Research

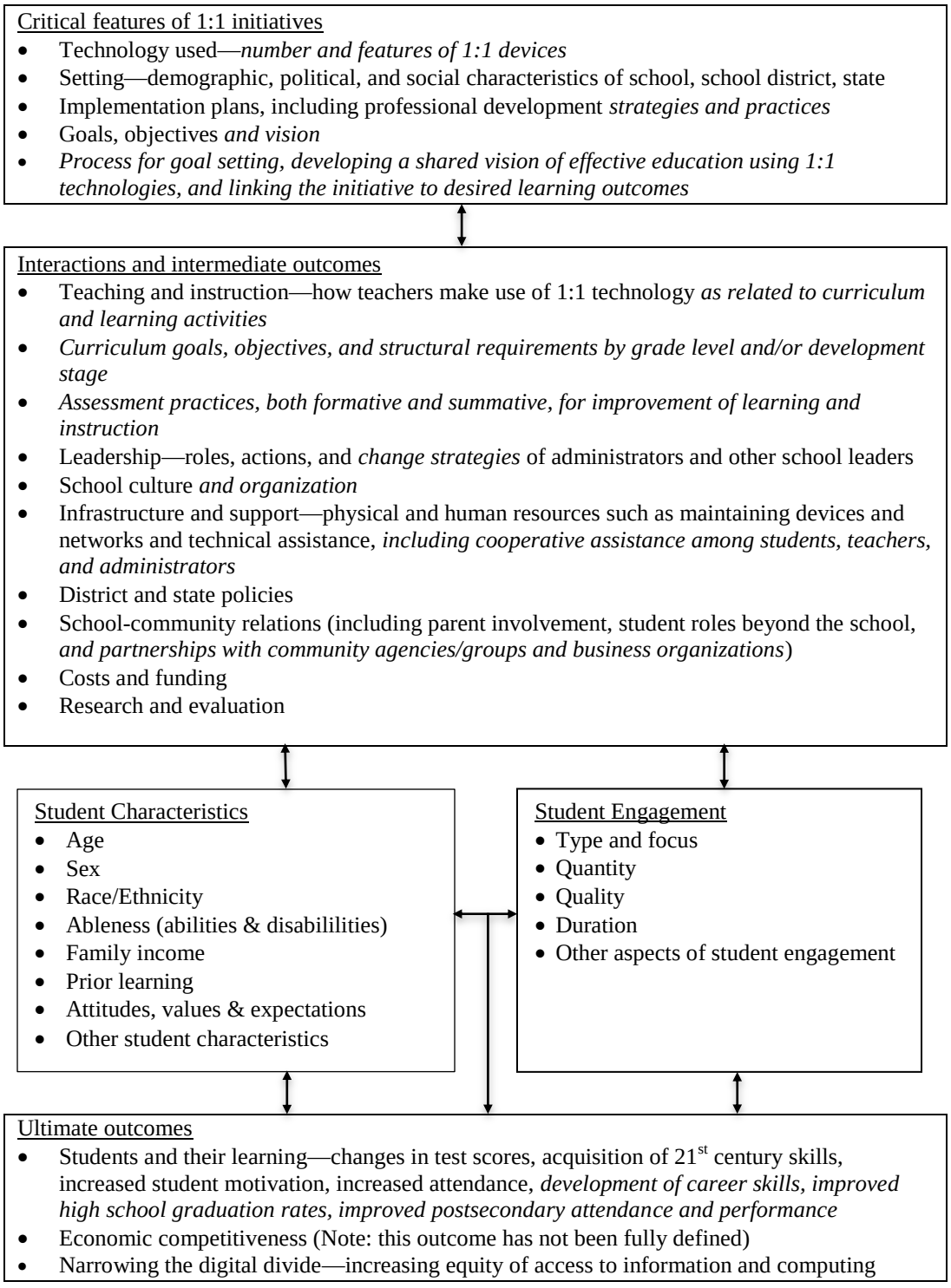
Based on findings from the meta-synthesis and the gaps we identified in describing 1:1 technology outcomes, implementation and funding, the authors assert that the research framework and agenda offered by Zucker (2004) remains a useful guide for future research. Consistent with our results, Zucker (2004, p. 372) observed:

> . . . reviews of research on 1:1 computing typically provide relatively "soft" evidence for their conclusions. Research has not yet provided policymakers with enough hard evidence of the benefits and costs of 1:1 computing to help them determine if the initiatives are worth what they cost, nor has research established the mix of factors that make 1:1 computing more or less effective.

To advance knowledge about 1:1 initiatives, Zucker (2004) proposed a "system level" (school, district, or state) research framework in contrast to a classroom focus that also could guide inquiry. At the system level, the framework includes three factors: critical features of 1:1 initiatives; interactions and intermediate outcomes; and ultimate outcomes. The theory embedded within Zucker's research framework posits that (A) critical features of 1:1 technology initiatives impact (B) interactions and intermediate outcomes, which in turn impact (C) ultimate outcomes.

From the current meta-synthesis findings on research in 1:1 initiatives, the authors think it is reasonable to extend the Zucker (2004) research framework (shown in regular font) in four significant ways as shown in Figure 7: (1) identifying additional key variables within each factor (shown in italics); (2) signifying interactions between factors (shown as two-way arrows); (3) adding student characteristics as a potent moderating variable; and (4) adding student engagement as a critical mediating variable for ultimate outcomes.

Figure 6. Proposed OERI Framework for Research on 1:1 Technology Initiatives in K-12 Education (adapted from Zucker, 2004)



The following "model" for future research, and its hypotheses, is suggested by the proposed OERI research framework for 1:1 technology initiatives:

- Student outcomes are most directly impacted by the interaction of student characteristics and student quality of learning effort—which in turn are most directed impacted by
- the interaction of technology usage with curriculum, instruction and assessment—which in turn are most directly impacted by
- the interaction of professional development, school culture and leadership, infrastructure and support for 1:1 technology use, school-parent-community-business relations and partnerships, district and state policies, funding, research and evaluation—which in turn are most directly impacted by
- the interaction of the goals and objectives of the 1:1 technology initiative, the process for setting those goals and developing a shared vision, the quality of plans for implementing and managing the 1:1 technology initiative, the characteristics of the setting (school, district, local community, and state), and the number and features of 1:1 devices in use.

This revised research framework is more complex than the one proposed by Zucker (2004) with its added variables and multiple interactions, and more closely reflects the range of challenges for successful 1:1 technology initiatives in K-12 education. Equally important, it helps to construct a research agenda that can better inform both practitioners and researchers for enhancing student learning with 1:1 technologies.

We are proposing that the framework illustrated in Figure 7 serve as an organizing scheme for OERI research on 1:1 technologies. With this purpose in mind, the research framework can serve as a tool both for inventorying what we know and do not know with regard to 1:1 technology and for identifying high priority questions for OERI research. Rather than illustrate the kinds of research questions that can be generated with this framework, because Zucker (2004) already does that effectively, attention in the remainder of this section is given to key considerations for OERI research priorities moving forward with district planning and implementation of 1:1 programs.

Student outcomes. The most common measures of student outcomes currently used by OERI districts are Missouri Assessment Program (MAP) tests in content areas. With the possible exception of disadvantaged students, neither consistent nor strong evidence exists that 1:1 programs improve student achievement as measured by standardized state tests. This may change as new tests are developed for Common Core curriculum goals and objectives, if those tests are significantly different than the ones currently used. However, 1:1 technology initiatives are more broadly aimed at student learning that include but go beyond achievement testing. For example, 1:1 initiatives likely improve 21st century skills such as ability to work independently, be critical in consuming information, completing larger or more complex projects, and working collaboratively and expansively with peers and the home and surrounding communities. Likewise, they seem to be beneficial for writing achievement. The development of career skills could be another focus for student outcomes. While some districts currently may be using

measures for some of these skills, it is highly probable that new measures will need to be developed across OERI districts for assessing 21st century skills and possibly career skills development. The cooperative development and use of such measures could be a high priority research activity for OERI. Also, collaborative research across OERI districts in the follow-up of graduates beyond high school and into postsecondary education and other venues also would be possible, especially with state longitudinal databases.

Professional development and implementation. Much is hidden within the implementation arena and its associated research questions. On the one hand, professional development is essential for the success of 1:1 technology initiatives because 1:1 programs point toward a significant shift from teacher-centered instruction (i.e., the teacher is the content expert, and the teacher's role is to convey the information and skills that students' need to master) to learner-centered instruction (i.e., the teacher is an instructional manager, coach, and designer of effective learning environments that include, but are not limited to, differentiated instruction, formative assessment, and engaging learners through inquiry and project methods). This shift requires a different outlook and set of skills than teachers have traditionally performed or been prepared for. On the other hand, relying on scheduled days for professional development is a limited conception for the transformative role of teachers in 1:1 programs. Professional learning communities and other approaches for ongoing collaborative professional development with colleagues would seem to be more suitable for 1:1 programs that are sensitive to the critical role played by teachers and the fact that teachers vary in their beliefs, values, and skills for implementing 1:1 programs. Successful implementation of 1:1 initiatives will depend on the several factors shown in Figure 7 as "critical features of 1:1 initiatives" and "interactions and intermediate outcomes." No single enabling factor is more important than teacher commitment and teacher skills related to technology as well as to instructional design and assessment.

Funding and costing. Along with student outcomes assessment, an understanding of the costs of 1:1 programs and how they will be funded is essential for successful implementation and sustainability. Based on sketchy evidence available in our meta-synthesis, 1:1 technology programs appear expensive, but perhaps not drastically more expensive than investments in other educational technologies. In fact, with 1:1 initiatives, there might be savings in some areas of current expenditures that could be allocated to the 1:1 program. There is meager national data to compare costs of 1:1 initiatives with similar programs or with non-1:1 programs. A high priority research objective for OERI could be the development or acquisition of a valid instrument for collecting and analyzing the full costs of 1:1 programs in member districts. For example, this objective can be aided by the Total Cost of Ownership (TCO) calculator available from the Consortium for School Networking (http://www.cosn.org/). This step, along with exploring a range of 1:1 funding options, is necessary to be in a position to answer perhaps the most important overall question likely to be raised in each OERI district: What is the cost-benefit of the 1:1 technology initiative, and are the returns on investment greater than other alternatives? As a side note, our meta-synthesis did not uncover any 1:1 research reviews or individual studies that included BYOD (Bring Your Own Device) programs, which could be another facet of research if any of the OERI members pursue that option.

Conclusions

This review attempted to compile and analyze information from systematic and non-systematic reviews to address OERI-generated questions regarding student outcomes, implementation and planning, and cost considerations in 1:1 technology initiatives. It is clear that 1:1 technology typically increases students' use of computers and literacy in using computers, has small but significant effects on writing outcomes, probably has positive effects on 21st century skills like collaboration, self-direction, and utilization of a range of learning resources, and has mixed or negligible effects in other areas of achievement like math, science, reading or social studies. Likewise, it is probable that implementation is most effective when 1:1 educational technology initiatives include provision of thorough, staged professional development, infrastructure and technical support, and district-school-teacher leadership and collaboration for student-centered teaching methods and applications. Key funding issues include securing sufficient financial resources, usually from multiple sources, for the initial acquisition, sustainability and upgrading of 1:1 resources.

Findings and implications from our review also stress the need for ongoing research and evaluation of 1:1 initiatives, including cost-benefit analyses returns on investment (ROI) in relation to non-1:1practices and other educational innovations. Drawing on and adapting the work of Zucker (2004), the authors provide a research framework and suggest priorities for future research to address questions left unanswered by this meta-synthesis.

OERI districts are in a unique position to become a national leader in research and empirically-based best practices for 1:1 technology initiatives. Each member district is a worthy case study linked to other OERI districts through a common goal: to enhance student learning by transforming teaching and learning environments through 1:1 technologies. While many features of 1:1 programs will vary by district, the common purpose that unites OERI districts and member commitments to learning with and from one another positions OERI well for the future.

References Cited in Text

Abrami, P. C., Borokhovski, E., Bernard, R. M., Wade, C. A., Tamim, R., Persson, T., Bethel, E. C., Hanz, K., & Surkes, M. A. (2010). Issues in conducting and disseminating brief reviews of evidence. *Evidence and Policy*, 6(3), 371-389.

Anytime, Anywhere Learning Foundation. (n.d.). Retrieved from http://www.aalf.org/

Bakia, M., Means, B., Gallagher, L., Chen, E., & Jones, K. (2009). *Evaluation of the enhancing through technology program*. Washington, DC: Department of Education. Available from http://www2.ed.gov/rschstat/eval/tech/netts/finalreport.pdf.

Bethel, E. C., & Bernard, R. M. (2010). Developments and trends in synthesizing diverse forms of evidence: Beyond comparisons between distance education and classroom instruction. *Distance Education*, 31(3), 231-256.

Consortium for School Networking. (n.d.). Retrieved from http://www.cosn.org/

Cooper, H. M. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research*, 52(2), 291-302.

Cornelius-White, J. H. D., & Harbaugh, A. P. (2010). *Learner-centered instruction: Building relationships for student success.* Thousand Oaks, CA: Sage.

Darling, et al. (2010)—REVIEW OF PROFESSIONAL DEVELOPMENT BEST PRACTICES

Government of Alberta: Education. (2012). Retrieved from http://education.alberta.ca/admin/technology/emerge-1:1.aspx/

Hemingway, P., & Brereton, N. 2009). What is a systematic review? Hayward Medical Communications. Available from http://www.medicine.ox.ac.uk/bandolier/painres/download/whatis/Syst-review.pdf.

Irving Independent School District. (n.d.). *Documents for 1-to-1 laptop distribution*. Retrieved from http://www.irvingsd.net/one2one/documents.htm/

K-12 Computing Blueprint. (2010). Retrieved from http://www.k12blueprint.com/k12/blueprint/index.php/

Khan, K. S., Kunz, R., Kleijnen, J. & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the Royal Society of Medicine*, 96, 118-121.

Maine International Center for Digital Learning. (2012). Retrieved from http://www.micdl.org/

One Child Per Laptop. (n.d.) Retrieved from http://one.laptop.org/

Penuel, W. R. (2006). Implementation and effects of 1:1 computing initiatives: A research synthesis. *Journal of Research on Technology in Education*, 38(3), 329-349.

Project Red: Revolutionizing Education. (2009). Retrieved from http://www.projectred.org/

Rockman et al. (2012). Retrieved from http://www.rockman.com/

State Educational Technology Directors Association. (2008). Retrieved from http://setda.org/

Ubiquitous Computing Evaluation Consortium. (2003). Retrieved from http://www.ubiqcomputing.org/lit_review.html/

Weston, M. E., & Bain, A. (2010). The end of techno-critique: The naked truth about 1:1 laptop initiatives and educational change. *The Journal of Technology, Learning, and Assessment, 9*, 6, 4-25.

Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research, 30*, 371-388.

Zucker, A. A., & Light, D. (2009). Laptop programs for students. *Science*, 323 (5910), 82-85.

Complete Set of References for Meta-Synthesis

Reference Notations

[1] Research reports retrieved but did not pass the screening criteria for further consideration (n=69)

[2] Research reports retrieved and screened but did not pass the quality criteria for inclusion as a systematic review of research on 1:1 technology initiatives in K-12 education (n=24)

[3] Systematic reviews that include but go beyond research on 1:1 technology initiatives in K-12 education (n=5)

[4] Systematic reviews of research on 1:1 technology initiatives in K-12 education (n=4)

[5] Unduplicated references cited in the four selected systematic reviews of research on 1:1 technology initiatives in K-12 education (n=131)

[5-1a] = Penuel, et al. (2002)

[5-1b] = Penuel, W. R. (2005)

[5-2] = Bethel, E. C., Bernard, R. M., Abrami, P. C., & Wade, A. C. (2008)

[5-3] = Fleisher, H. (in press, 2011)

[6] Most current empirical studies of research on major state and local1:1 technology initiatives in K-12 education not included in four systematic reviews of research on 1:1 technology initiatives in K-12 education (n=20)

[7] Additional references cited in text (n=22)

Abell Foundation (2008). *1:1 computing in public schools: Lesson from "laptops for all" programs*. ERIC ED505074 Available from http://www.eric.ed.gov/PDFS/ED505074.pdf. [2]

Abrami, P. C., Borokhovski, E., Bernard, R. M., Wade, C. A., Tamim, R., Persson, T., Bethel, E. C., Hanz, K., & Surkes, M. A. (2010). Issues in conducting and disseminating brief reviews of evidence. *Evidence and Policy*, *6*(3), 371-389. [7]

Abrams, R. (2000). Laptop computers in an all-girls school: hearing the student voice in an evaluation of technology use. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. Available from http://www.notesys.com/LinkSite/Hewitt_AERA2000v5.pdf. [5-2]

Alberta Education (2010). Emerge 1:1 laptop learning initiative: Final report. Edmonton, AB: Author. Available from http://www.education.alberta.ca/admin/technology/emerge-1:1.aspx. [6]

Alberta Education (2011). Implementing 1:1 laptop learning in Alberta's schools. Edmonton, AB: Author. Available from http://www.education.alberta.ca/admin/technology/emerge-1:1.aspx. [2]

Apple, Inc. (2007). Research on 1 to 1 learning programs: A review. Available from http://www.projectred.org/uploads/1-1%20Research%20Brief.pdf. [2]

Apple, Inc. (2008). Apple classrooms of tomorrow—today: Learning in the 21st century. Cupertino, CA: Author. Available from http://ali.apple.com/acot2/global/files/ACOT2_Background.pdf. [1]

Anytime, Anywhere Learning Foundation. (n.d.). Retrieved from http://www.aalf.org/ [7]

Argueta, R., Huff, J., Tingen, J., & Corn, J. O. (2011). Laptop initiatives: Summary of research across six states. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/podcast_episodes/white-paper-series/laptop-initiatives-summary-of-research-across-six-states.pdf. [6]

Bakia, M., Means, B., Gallagher, L., Chen, E., & Jones, K. (2009). Evaluation of the enhancing through technology program. Washington, DC: Department of Education, Office of Planning, Evaluation, and Policy Development. Available from http://www2.ed.gov/rschstat/eval/tech/netts/finalreport.pdf. [1, 7]

Balanskat, A., & Garoia, V. (2010). Netbooks on the rise: European overview of national laptop and netbook initiatives in schools. Brussels, Belgium: European Schoolnet. Available from http://resources.eun.org/insight/Netbooks_on_the_rise.pdf. [1]

Banks, K. E. (2007). Interim report: Evaluation of the Kent School District's Technology Academy. Kent, WA: Data Detectives. [5-2]

Barrios, T. (2004). Laptops for learning: Final report and recommendations of the laptops for learning task force. Laptops for Learning Task Force. Available from http://etc.usf.edu/L4L/Report.pdf. [5-2]

Bartels, F. (2002). Reflections on the RCDS Laptop Program After Three Years. Available from http://www.learningwithlaptops.org/files/3rd%20Year%20Laptop%20Prog.pdf. [5-2]

Beaudry, J. S. (2004). The impact of Maine's 1:1 laptop program on middle school teachers and students: Use of laptop computers and classroom assessment - Are teachers making the connections?, Maine Learning Technology Initiative Research Reports. Maine Education Policy Research Institute. Available from http://www.usm.maine.edu/cepare/Reports/MLTI_Report4.pdf. [5-2]

Bebell, D. (2005). Technology promoting student excellence: An investigation of the first year of 1: 1 computing in New Hampshire middle schools (p. 50). Boston, MA: Technology and Assessment Study Collaborative, Boston College. [5-2]

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *Journal of Technology, Learning, and Assessment*, *9*(1). Available from http://www.jtla.org. [2]

Bebell, D. & Kay, R. (2010). One to one computing: A summary of the quantitative results from the Berkshire Wireless Learning Initiative. *Journal of Technology, Learning, and Assessment, 9*(2). Available from http://www.jtla.org. [6]

Bebell, D., & Russell, M. (2005). Berkshire Wireless Learning Initiative Phase 1 Final Evaluation Plan. Westborough, MA: Technology and Assessment Study Collaborative, Boston College. [5-2]

Belanger, Y. (2000). Laptop Computers in the K-12 Classroom ERIC Digest, Clearinghouse in Information Technology EDO-IR-2000-05. ERIC Clearinghouse on Information and Technology. Available from http://www.ericdigests.org/2001-1/laptop.html. [5-2]

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research*, *74*(3), 379-439. [1]

Bernard, R. M., Bethel, E. C., Abrami, P. C., & Wade, C. A. (2007). DMI-ELS ETSB Laptop Research Project: Report on the Grade Three Students. Montreal, QC: Centre for the Study for Learning and Performance. Available from http://doe.concordia.ca/cslp/Downloads/PDF/ETSB_Yr3report050707.pdf. [5-2]

Bernstein Strategy Group (2010). *Profiles in innovation*. A report commissioned by the National Coalition for Technology in Education and Training. Available from http://www.cosn.org/Portals/7/docs/NCTET_Report.pdf. [1]

Bethel, E. C., & Bernard, R. M. (2010). Developments and trends in synthesizing diverse forms of evidence: Beyond comparisons between distance education and classroom instruction. *Distance Education*, *31*(3), 231-256. [7]

Bethel, E. C., Bernard, R. M., Abrami, P. C., & Wade, A. C. (2008). Ubiquitous computing in K-12 classrooms: A systematic review. The Eighth Annual Campbell Collaboration Colloquium, Vancouver, BC, May 12-14, 2008. Available from http://ecbethel.com/Edward_C_Bethel/research_files/Betheletal08onetooneC2.pdf. [4]

Blazer, C. (2009). *Literature review: Educational technology*. Miami, FL: Office of Assessment, Research, and Data Analysis, Miami-Dade County Public Schools. Available from http://drs.dadeschools.net/Reports/Ed%20Technology.pdf. [1]

Bolstad, R. (2005). Digital opportunities pilot project (2001-2003): Evaluation of Notebook Valley. Evaluation, Wellington, NZ: New Zealand Council for Educational Research. Available from http://www.minedu.govt.nz/web/downloadable/dl10234_v1/digi-opps-notebook-valley.pdf. [5-2]

Bonifaz, A., & Zucker, A. (2004). *Lessons learned about providing laptops for all students*. Newton, MA: Education Development Center. Available from http://www.neirtec.org/laptop/laptoplessonsrprt.pdf. [1]

Boser, U. (2011). *Return on educational investment: A district-by-district evaluation of U.S. educational productivity*. Washington, DC: Center for American Progress. Available from http://www.americanprogress.org/issues/2011/01/pdf/dwwroi.pdf. [1]

Boyd, S. (2002). *Literature review for the evaluation of the digital opportunities projects*. Wellington: New Zealand Council for Educational Research. Available from http://edcounts.squiz.net.nz/__data/assets/pdf_file/0005/6989/digopps.pdf. [2]

Cameron, C. A., & Lee, K. (1997). Bridging the gap between home and school with voicemail technology. *The Journal of Educational Research, 90*, 182-190. [5-1a]

Campbell, M., & Woodbridge, J. (2004, July 1). Observations, Reflections, & Research of a Laptop Classroom. Technology & Learning. Available from http://intranet.clayton.k12.mo.us/techsup/FoodForThought/ResearchOfALaptop%20Classroom.pdf. [5-2]

Cates, W. M. (2005). Bethlehem Area School District 1:1 Laptop Initiative: Final Report. Evaluation, Bethlehem, PA: Bethlehem Area School District. [5-2]

Center for Implementing Technology in Education (2007). Technology implementation in schools: Key factors to consider. Available from: http://www.cited.org/index.aspx?page_id=187. [1]

Center for Technology in Education, Johns Hopkins University. (2006). Talbot County Public Schools 1:1 Laptop Initiative External Evaluation. Center for Technology in Education. Available from http://www.tcps.k12.md.us/uploads/1-1/JHU%20Laptop%20Report.pdf. [5-2]

Chang, H.-H., Henriquez, A., Honey, M., Light, D., Moeller, B., & Ross, N. (1998). *The Union City story: Education reform and technology students' performance on standardized tests.* New York: Center for Children and Technology. [5-1a, 5-2]

Chapman, G. (1998, September 1). DIGITAL NATION: Push to Trade Class Textbooks for Laptop PCs Is a Misuse of Technology. *Teacher Librarian, 26*(1). [5-2]

Chessler, M., Rockman, S., & Walker, L. (1998). Powerful tools for schooling: Second year study of the laptop program. San Francisco, CA: Rockman et. al. [5-2]

Cheung, A. C., & Slavin, R. E. (2011). *The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis*. Baltimore, MD: Johns Hopkins University, Center for Data-Driven Reform in Education. Available from http://www.bestevidence.org/word/tech_math_sep_09_2011.pdf. [3]

Consortium for School Networking. (n.d.). Retrieved from http://www.cosn.org/[7]

Constant, M. D. (2011). 1:1 laptop project: Perceptions of teachers, parents, and students. *Dissertations.* Paper 5. Available from http://digitalcommons.wku.edu/diss/5. [1]

Cooper, H. M. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research*, 52(2), 291-302. [7]

Corn, J. O., Huff, J. D., Halstead, E. O., & Patel, R. (2011). *Examining issues critical to a 1:1 learning environment: Student outcomes*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/examining-issues-critical-to-a-11-learning-environment-student-learning-outcomes.pdf. [6]

Corn, J. O., & Mollette, M. (2010). Research highlights from evaluation studies in NC schools. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/presentation_posts/evaluation-of-nc-11-learning-initiative/ncties-2010a.pdf. [6]

Corn, J., Oliver, K., Hess, C.E., Halstead, E.O., Argueta, R., Patel, R., Tingen, J., & Huff, J. (2010). A computer for every student: Lessons learned about planning and implementing a successful 1:1 learning initiative in schools. *Educational Technology, 50* (6), 11-17. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/a-computer-for-every-student-and-teacher-lessons-learned.pdf. [6]

Corn, J. O., Patel, R. K., Hess, C. E., Stanhope, D. S., Tingen, J., & Argueta, R. (2010). *Examining issues critical to a 1:1 learning environment: Principal leadership*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/examining-issues-critical-to-a-11-learning-environment-principal-leadership.pdf. [6]

Corn, J. O, Patel, R., Huff, J., & Halstead. E. (2010). NC 1:1 learning technology initiative: Preliminary EOC summary. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/nc-11-learning-technology-initiative-preliminary-eoc-summary.pdf. [6]

Corn, J., Tagsold, J. K., & Patel, R. K. (2011). The tech-savvy teacher: Instruction in a 1:1 learning environment. *Journal of Educational Research and Practice*, 1(1), 1-22. Available from http://www.publishing.waldenu.edu/jerap/vol1/iss1/9/. [6]

Corn, J. O., Tagsold, E. O., Townsend, M., & Patel, R. (2011). *North Carolina 1:1 learning initiative evaluation final report: Vance County Schools/Golden LEAF Foundation*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-vance-schools-11-learning-initiative/north-carolina-11-learning-initiative-evaluation-final-report.pdf. [6]

Corn, J. O., Tingen, J., & Patel, R. (2010). *Examining issues critical to a 1:1 learning environment: Instructional practice*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/examining-issues-critical-to-a-11-learning-environment-instructional-practice.pdf. [6]

Corn, J. O., Tingen, J., & Patel, R. (2011). *Examining issues critical to a 1:1 learning environment: Special needs*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-nc-11-learning-initiative/examining-issues-critical-to-a-11-learning-environment-special-needs-students.pdf. [6]

Cornelius-White, J. H. D., & Harbaugh, A. P. (2010). *Learner-centered instruction: Building relationships for student success.* Thousand Oaks, CA: Sage. [7]

Couse, L. J., & Chen, D. W. (2010). A tablet for young children? Exploring its viability for early childhood education. *Journal of Research on Technology in Education, 43*(1), 75-98. [6]

CRF & Associates. (2003). The Impact of Plato Learning, Inc. Technology in East Rock Magnet School. New Haven, CT: East Rock Magnet School. Available from http://www.projectred.org/uploads/East_Rock_Impact_Study_final.pdf. [5-2]

Daitzman, P. (2003). *Evaluation of the National Model Laptop Program Technology Literacy: A journey into the global learning community.* New Haven, CT: East Rock Global Magnet School. [5-1b]

Davies, A. (2004). *Finding proof of learning in a 1:1 computing classroom*. Maine Learning Technology Initiative. Courtenay, B.C.: Connections Publishing. [5-1b, 5-2]

Davis, D., Garas, N., Hopstock, P., Kellum, A., & Stephenson, T. (2005). *Henrico County Public Schools iBook Survey Report*. Arlington, VA: Henrico County Public Schools. Available from http://www.henrico.k12.va.us/pdf/technology/hcreport.pdf. [5-1b, 5-2]

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science*, 323, 66-69. [1]

Dinnocenti, S. T. (2002). *Laptop computers in an elementary school: Perspectives on learning environments from students, teachers, administrators, and parents.* Unpublished doctoral dissertation, University of Connecticut, Storrs, CT. [5-1b]

Donnelly, M. B., Dove, T., & Tiffany-Morales, J. (2002). *Technology-related professional development in the context of educational reform: A literature review*. Arlington, VA: SRI International. Available from http://policyweb.sri.com/cep/publications/SRI_PD_Lit_Review_2002.pdf. [1]

Donovan, L., & Grimes, D. (2006). Laptops for Learning Year 2: 2005-2006. Fullerton, CA: Fullerton School District. [5-2]

Donovan, L., Green, T., & Hartley, K. (2010). An examination of 1:1 computing in the middle school: Does increased access bring about increased student engagement? *Journal of Educational Computing Research*, *42*(4), 423-441.[1]

Donovan, L., Hartley, K., & Strudler, N. (2007). Teacher concerns during initial implementation of a 1:1 laptop initiative at the middle school level. *Journal of Research on Technology in Education*, *39*(3), 263–286. [5-3]

Dunleavy, M., Dexter, S., & Heinecke, W. F. (2007). What added value does a 1: 1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning*, *23*(5), 440-452. [5-2, 5-3]

Dunleavy, M., & Heinecke, W. F. (2008). The impact of 1:1 laptop use on middle school math and science standardized test scores. *Computers in the Schools*, *24*, 7–22. [5-3]

Education Commission of the States (2006). Technology in education. *The Progress of Education Reform*, *6*(6). Available from http://www.eric.ed.gov/PDFS/ED490992.pdf. [1]

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *ETR&D*, *47*(4), 47-61. [1]

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42*(3), 255-284. Available from http://www.eric.ed.gov/PDFS/EJ882506.pdf. [1]

Fairman, J. (2004). *Trading roles: Teachers and students learn with technology.* Orono, ME: Maine Education Policy Research Institute, University of Maine Office. [5-1b]

Faulk, H. R. (2003). Quaker Valley School District: An Evaluation Report of the Digital School District Project. Evaluation, Quaker Valley, PA: Pennsylvania Digital School Districts. [5-2]

Fleischer, H. (2011). Towards a phenomenological understanding of Web 2.0 and knowledge formation. *Educational Inquiry*, *2*(3), 535-549. [1]

Fleisher, H. (in press, 2011). What is our current understanding of 1:1 computer projects: A systematic narrative research review. *Educational Research Review*, doi:10.1016/jedurev.2011.11.004. [4]

Flores, J. G. (2010). *Expanding the classroom: Mobile distance learning across America*. United States Distance Learning Association. Available from http://usdla.org/assets/pdf_files/USDLAWhitePaper.English.FINAL.9.15.pdf. [1]

Freiman, V., Beauchamp, J., Blain, S., Lirette-Pitre, N., & Fournier, H. (2010). Does 1:1 access to laptops improve learning: Lessons from New Brunswick's individual laptop school initiative? *Procedia Social and Behavioral Sciences*, 2, 5686–5692. [6]

Friesen, S., & Lock, J. V. (2010). *High performing districts in the application of 21st century learning technologies: Review of the research*. Edmonton, Alberta (CA): College of Alberta School Superintendents. Available from http://o.b5z.net/i/u/10063916/h/Communications/CASS_Research_Paper_2_Friesen__Lock_Characteristics_of_High_Performing_Districts_in_the_Application_of_Learning_Technologies.pdf. [2]

Fryer, W. (2004a). *Assessing the impact of one to one technology immersion on student attendance: Chasing shadows or panacea for educational reform*. Available from http://www.wesfryer.com/onetoone/onetoone_attendance.pdf. [5-2]

Fryer, W. (2004b). *Conditional support of one to one technology immersion from a critical educational theorist's perspective*. Available from http://www.wesleyfryer.com/onetoone/conditional_onetoone_support.pdf. [5-2]

Fuchs, T., & Woessmann, L. (2005). *Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and at school*. Munich, Germany: Institute for Economic Research at the University of Munich. Available from http://www.cesifo.de/pls/guest/download/Ifo%20Working%20Papers%20(seit%202005)/IfoWorkingPaper-8.pdf. [5-2]

Gardner, J., Morrison, H., Jarman, R., Reilly, C., & McNally, H. (1992). *Pupils' learning and access to information technology: An evaluation*. Belfast, N. Ireland: School of Education, The Queen's University of Belfast. Available from http://arrts.gtcni.org.uk/gtcni/bitstream/2428/8353/1/PLAIT%2520Full%2520Report%2520-%25201992.pdf. [5-2]

Gardner, J., Morrison, H., Jarman, R., Reilly, C., & McNally, H. (1994). *Personal portable computers and the curriculum*. Practitioner MiniPaper 13. Edinburgh, Scotland: Scottish Council for Research in Education. Available from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.98. [1]

Garthwait, A., & Weller, H. G. (2005). A year in the life: Two seventh grade teachers implement 1:1 computing. *Journal of Research on Technology in Education*, 37(4), 361–377. [5-2, 5-3]

Gaynor, I. W., & Fraser, B. J. (2003). *Online collaborative projects: A journey for two Year 5 technology rich classrooms.* Paper presented at the Western Australian Institute for Educational Research Forum. [5-1b]

Getting results with laptops (2004). *Technology & Learning*, 25(3). Available from http://www.techlearning.com/article/42137. [1]

Goldberg, A., Russell, M., & Cook, A. (2003). The effect of computers on student writing: A meta-analysis of studies from 1992 to 2002. *Journal of Technology, Learning, and Assessment, 2*(1). Available from http://www.jtla.org. [2]

Government of Alberta: Education. (2012). Retrieved from http://education.alberta.ca/admin/technology/emerge-1:1.aspx/[7]

Grant, L. (2009). *Children's role in home-school relationships and the role of digital technologies*. Bristol, UK: Futurelab.Available from www.futurelab.org.uk. [1]

Grant, M. M., Ross, S. M., Wang, W., & Potter, A. (2005). Computers on wheels: an alternative to 'each one has one'. *British Journal of Educational Technology*, 36(6), 1017-1034. [5-2]

Gravelle, P. B. (2003). *Early evidence from the field–the Maine Learning Technology Initiative: Impact on the digital divide*. University of Southern Maine. Available from http://www.usm.maine.edu/cepare/pdf/mlti/Iimpact%20on%20the%20digital%20divide%20as%20OCCASIONAL%20PAPER%202.pdf. [5-2]

Gray, L., Thomas, N., and Lewis, L. (2010). *Teachers' use of educational technology in U.S. public schools: 2009* (NCES 2010-040). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Available from http://nces.ed.gov/pubs2010/2010040.pdf. [1]

Greaves, T., Hayes, J., Wilson, L., Gielniak, M., & Peterson, E. (2010a). *Project RED: Key findings*. ISTE Presentation June 28, 2010. Available from http://projectred.org/uploads/ISTE%202010%20Presentation%20v2.pdf. [1]

Greaves, T.; Hayes, J.; Wilson, L.; Gielniak, M.; & Peterson, E. (2010b). *The technology factor: Nine keys to student achievement and cost-effectiveness*. Shelton, CT: MDR. Available from http://www.pearsonfoundation.org/downloads/ProjectRED_TheTechnolgyFactor.pdf/. [2]

Greenfield, P. M. (2009). Technology and informal education: What is taught, what is learned. *Science*, 323, 69-71. [1]

Grimes, D., & Warschauer, M. (2008). Learning with laptops: A multi-method case study. *Journal of Educational Computing Research*, 38(3), 305–332. [5-3]

Gulek, J. C. & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *Journal of Technology, Learning, and Assessment, 3*(2). Available from http://www.jtla.org. [5-1b, 5-3]

Gwaltney, L. (1998). *Year one interim report of the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Author. [5-1a]

Gwaltney, L. (1999). *Year two interim report of the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services. [5-1a]

Gwaltney, L. (2000). *Year three final report of the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services. [5-1a]

Hadeed, L. (2000). *Effects of using the Anytime Anywhere Learning Model (laptop program) for the enhancement of problem solving and critical thinking skills*. Pilot Study, Tampa, FL: University of South Florida. Available from http://www.coedu.usf.edu/itphdsem/eme7938/lh800.pdf. [5-2]

Hall, G. E. (2010). Technology's achilles heel: Achieving high-quality implementation. *Journal of Research on Technology in Education*, 42(3), 231-253. Available from http://zellerandassociates.com/nl533rdg/15JRTE_Sprng2010_Hall_MembersOnly.pdf. [1]

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education,* 43(3), 211-229. [1]

Harris, M. J. (2010). *Impactful student learning outcomes of 1:1 student laptop programs in low socioeconomic schools*. Unpublished dissertation submitted for the Doctor of Education in Educational Leadership at San Francisco State University. Available from http://www.st-andrews.org/Customized/uploads/Parents/Leaflet/Dec_15/MJH_Dissertation.pdf. [1]

Harris, W. J., & Smith, L. (2004). *Laptop use by seventh grade students with disabilities: Perceptions of special education teachers.* Orono, ME: Maine Education Policy Research Institute, University of Maine Office. [5-1b, 5-2]

Haynes, C. (1996). *The effectiveness of using laptop computers with middle school students identified as being inhibited writers.* Unpublished doctoral dissertation. Cincinnati, OH: Union Institute. [5-1a]

Hemingway, P., & Brereton, N. 2009). What is a systematic review? *Hayward Medical Communications*. Available from http://www.medicine.ox.ac.uk/bandolier/painres/download/whatis/Syst-review.pdf.[7]

Hill, J. R., & Reeves, T. C. (2004). *Change takes time: The promise of ubiquitous computing in schools: A report of a four year evaluation of the laptop initiative at Athens Academy* (p. 73). Evaluation, Athens, GA: University of Georgia. Available from http://lpsl.coe.uga.edu/projects/aalaptop/pdf/finalreport.pdf. [5-1b, 5-2]

Hill, J., Reeves, T., Grant, M., & Wang, S. (2002). *The impact of portable technologies on teaching and learning: Year two report*. Athens, GA: Athens Academy. Available from http://lpsl.coe.uga.edu/projects/aalaptop/image/PDF/AAYearTwoRpt.pdf. [5-2]

Holcomb, L. G. (2009). Results & lessons learned from 1:1 laptop initiatives: A collective review. *TechTrends*, 53(6), 49-55. [2]

Hooker, M. (2008). *1:1 technologies/computing in the developing world: Challenging the digital divide*. Available from http://www.gesci.org/11-technologiescomputing-in-the-developing-world-challenging-the-digital-divide1.html?searched=Mary+Hooker&advsearch=oneword&highlight=ajaxSearch_highlight+ajaxSearch_highlight1+ajaxSearch_highlight2. [1]

Horn, M. B., & Staker, H. (2011). *The rise of K-12 blended learning*. Mountain View, CA: Innosight Institute. Available from http://www.projectred.org/uploads/The-Rise-of-K-12-Blended-Learning.pdf. [1]

Inan, F. A., & Lowther, D. L. (2010). Laptops in the K-12 classrooms: Exploring factors impacting instructional use. *Computers & Education*, 55(3), 937–944. [5-3]

Intel Corporation (2005). *Blueprint solutions for K-12 1:1 computing initiatives*. Available from http://www.k12blueprint.com/k12/blueprint/cd/02.PDF. [1]

Intel Corporation (2009). *Classroom elearning: Moving beyond PC labs*. Intel World Ahead Program, K-12. Available from http://www.intel.com/es_LA/itcenter/pdf/5777_IN_WA_COWs_WP_051111.pdf. [1]

Irving Independent School District. (n.d.). *Documents for 1-to-1 laptop distribution*. Retrieved from http://www.irvingsd.net/one2one/documents.htm/ [7]

Jaillet, A. (2004). What is happening with portable computers in schools? *Journal of Science Education and Technology, 13*(1), 115-128. [5-1b]

Jeroski, S. (2003). *Wireless writing project: Research report phase II*. Vancouver, BC (p. 35). Evaluation, Vancouver, BC: Horizon Research and Evaluation Inc. Available from http://www.prn.bc.ca/FSJ_WWP_Report03.pdf. [5-1b, 5-2]

Jeroski, S. (2004). *Implementation of the Wireless Writing Program: Phase 3*. 2003-2004 (p. 35). Evaluation, Vancouver, BC: Horizon Research and Evaluation Inc. Retrieved January 25, 2007, from http://www.prn.bc.ca/WWP_Report04.pdf. [5-2]

Jeroski, S. (2005). *Research report: The Wireless Writing Program 2004-2005*. Vancouver, BC: Horizon Research and Evaluation Inc. Available from http://www.prn.bc.ca/wwp2005.pdf. [5-2]

Johnson, L., Adams, S., and Haywood, K., (2011). *The NMC horizon report: 2011 K-12 edition*. Austin, TX: The New Media Consortium. Available from http://www.nmc.org/pdf/2011-Horizon-Report-K12.pdf. [2]

Johnson, L. F., Smith, R. S., Smythe, J. T., & Varon, R. K. (2009). *Challenge-based learning: An approach for our time.* Austin, Texas: The New Media Consortium. Available from http://www.nmc.org/pdf/Challenge-Based-Learning.pdf. [1]

K-12 Computing Blueprint. (2010). Retrieved from http:www.k12blueprint.com/k12/blueprint/index.php/ [7]

Kadel, R. (2008). *Technology and student achievement—the indelible link*. ISTE Policy Brief. Washington, DC: International Society for Technology in Education. Available from http://www.k12hsn.org/files/research/Technology/ISTE_policy_brief_student_achievement.pdf. [1]

Keefe, D., Farag, P., & Zucker, A. (2003). *Annotated bibliography of ubiquitous computing evaluations*. Arlington, VA: SRI International.Available from http://www.ubiqcomputing.org/Reference.pdf. [5-2]

Keengwe, J., Schnellert, G., & Mills, C. (2011). Laptop initiative: Impact on instructional technology integration and student learning. *Education and Information Technologies*, DOI 10.1007/s10639-010-9150-8. [6]

Kemker, K., & Barron, A. (2004). *Laptop computers as a tool for authentic instruction.* Paper presented at the Annual Meeting of the National Educational Computing Conference, New Orleans, LA. [5-1b]

Kerr, K. A., Pane, J. F., & Barney, H. (2003). *Quaker Valley Digital School District: Early effects and plans for future evaluation.* Santa Monica, CA: RAND. [5-1b, 5-2]

Khan, K. S., Kunz, R., Kleijnen, J. & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the Royal Society of Medicine*, 96, 118-121. [7]

Klieger, A., Ben-Hur, Y., & Bar-Yossef, N. (2010). Integrating laptop computers into classroom: Attitudes, needs, and professional development of science teachers – A case study. *Journal of Science Education and Technology*, 19(2), 187–198. [5-3]

Kulik, J. A. (2003). *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. Arlington, VA: SRI International. Available from http://www.sri.com/policy/csted/reports/sandt/it/Kulik_ITinK-12_Main_Report.pdf. [3]

Lane, D. (2003a). Early evidence from the field: The Maine learning technology initiative: Impact on students and learning, early evidence from the field. Maine Education Policy Research Institute. [5-2]

Lane, D. (2003b). *The Maine learning technology initiative impact on students and learning.* Portland, ME: Center for Education Policy, Applied Research, and Evaluation, University of Southern Maine. [5-1b, 5-2]

Lavoie, M., Bernard, B., Abrami, P. C., & Wade, C. A. (2006). DMI-ELS: ETSB/SWLSB research project: Year 2 final report. Montreal, QC: Centre for the Study for Learning and Performance. [5-2]

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, 77(4), 575-614. [1]

Learning Cultures Consulting, Inc. (2006). *1:1 mobile computing: Literature review*. Edmonton, Alberta (CA): Alberta Education. Available from http://www.eric.ed.gov/PDFS/ED502920.pdf. [2]

Lei, J. (2010): Conditions for ubiquitous computing: What can be learned from a longitudinal study? *Computers in the Schools*, 27(1), 35-53. [1]

Lei, J., & Zhao, Y. (2006). What does 1:1 computing bring to schools? In C. Crawford, D. A. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2006* (pp. 1690-1694). Orlando, Florida: AACE. Available from http://go.editlib.org/p/22305. [5-2]

Lei, J., & Zhao, Y. (2008). 1:1 computing: What does it bring to schools? *Journal of Educational Computing Research*, 39(2), 97–122. [5-3]

Lemke, C., & Martin, C. (2003). 1:1 computing in Maine: A state profile. review. Metiri Group/SRI International. Available from http://www.metiri.com/NSF-Study/ME-Profile.pdf. [5-2]

Lemke, C., & Martin, C. (2004a). 1:1 computing in Indiana: A state profile. Metiri Group/SRI International. Available from http://www.metiri.com/NSF-Study/INProfile.pdf. [5-2]

Lemke, C., & Martin, C. (2004b). 1:1 computing in Michigan: A state profile. review, Metiri Group/SRI International. Available from http://www.metiri.com/NSF-Study/MIProfile.pdf. [5-2]

Lemke, C., & Martin, C. (2004c). 1:1 computing in Virginia: A state profile. Metiri Group/SRI International. Available from http://www.metiri.com/NSF-Study/VAProfile.pdf. [5-2]

Lemke, C., Coughlin, E., & Reifsneider, D. (2009). *Technology in schools: What the research says: An update*. Culver City, CA: Commissioned by Cisco. Available from http://www.cisco.com/web/strategy/docs/education/tech_schools_09_research.pdf. [3]

Lemke, C., Coughlin, E., Garcia, L., Reifsneider, D., & Baas, J. (2009). *Leadership for Web 2.0 in education: Promise and reality.* Commissioned by CoSN through support from the John D. and Catherine T. MacArthur Foundation. Culver City, CA: Metiri Group. Available from http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/started_laptops/raju_presentation/LeadershipCOSN_Web2.0_Raju.pdf. [1]

Li, S. C. (2010). Social capital, empowerment and educational change: A scenario of permeation of 1:1 technology in school. *Journal of Computer Assisted Learning*, 26, 284-295. [1]

Light, D., McDermott, M., & Honey, M. (2001, June). *Project Hiller: The impact of ubiquitous portable computing on an urban school.* Presentation at the National Educational Computing Conference, Chicago, IL. [5-1a]

Light, D., McDermott, M., & Honey, M. (2002). *Project Hiller: The impact of ubiquitous portable technology on an urban school.* New York: Center for Children and Technology, Education Development Center. [5-1b]

Lips, D. (2010). How online learning is revolutionizing K-12 education and benefiting students. *Backgrounder*, No. 2356. Available from http://www.heritage.org/research/reports/2010/01/how-online-learning-is-revolutionizing-k12-education-and-benefiting-students. [1]

Liu, C.-C.. & Milrad. M. (2010). 1:1 learning in the mobile and ubiquitous computing age. *Educational Technology & Society, 13* (4). 1-3. Available from http://www.ifets.info/journals/13_4/ets_13_4.pdf#page=6. [1]

Lou, Y., Abrami, P. C., & d'Apollonia, S. (2001). Small group and individual learning with technology: A meta-analysis. *Review of Educational Research*, 71(3), 449-521. [3]

Lowther, D. L., & Ross, S. M. (2003). *When each one has one: The influences on teaching strategies and student achievement of using laptops in the classroom.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL. [5-1b]

Lowther, D. L., Ross, S. M., & Morrison, G. R. (2001). *Evaluation of a laptop program: Successes and recommendations.* Paper presented at the National Education Computing Conference, Chicago, IL. Available from http://amoyemaat.org/lowther.pdf. [5-1a, 5-1b, 5-2]

Lowther, D., Ross, S. M., & Strahl, J. D. (2006). The influence of technology on instructional practices. *International Journal of Knowledge, Culture and Change Management*, vol. 6. Available from http://www.memphis.edu/crep/pdfs/The_Influence_of_Technology.pdf. [1]

Lowther, D., Ross, S., & Morrison, G. (2003). When each one has one: The influences on teaching strategies and student achievement of using laptops in the classroom. *Educational Technology Research and Development*, 51(3), 23-44. [5-2]

Lowther, D., Ross, S., Strahl, J. D., Inan, F. A., & Pollard, D. (2005). Freedom to learn program Michigan 2004-2005 evaluation report. MI: Michigan Department of Education. Available from http://www.ftlwireless.org/upload_3/FTL%20Year%201%20Evaluation%20Report%20FINAL%20cr.pdf. [5-2]

Lowther, D., Strahle, J. D., Inan, F. A., & Bates, J. (2007). *Freedom to learn program: Michigan 2005-06 evaluation report prepared for freedom to learn and the 1:1 institute*. Available from http://www.memphis.edu/crep/pdfs/Michighan_Freedom_to_Learn_Laptop_Program.pdf. [5-2]

Lowther, D., Strahl, J. D., Inan, F. A., & Ross, S. M. (2008). Does technology integration "work" when key barriers are removed? *Educational Media International*, 45(3), 195-213. [1]

Mabry, L., & Snow, J. Z. (2006). Laptops for high-risk students: Empowerment and personalization in a standards-based learning environment. *Studies in Educational Evaluation*, 32(4), 289–316. [5-3]

Maderthaner, P. (2007). *Laptop classrooms as catalysts of change? A review of research on the effects of laptop classrooms*. Published in Conference ICL2007, September 26 -28, 2007, Villach, Austria. Available from http://telearn.archives-ouvertes.fr/docs/00/25/71/22/PDF/204_Final_Paper.pdf. [2]

Maine International Center for Digital Learning. (2012). Retrieved from http://www.micdl.org/ [7]

Maninger, R. M., & Holden, M. E. (2009). Put the textbooks away: Preparation and support for a middle school 1:1 laptop initiative. *American Secondary Education*, 38(1), 5–33. [5-3]

Mann, D., Shakeshaft, C., Becker, J., & Kottkamp, R. (1999). *West Virginia Story: Achievement gains from a statewide comprehensive instructional technology program*. Charleston, WV: West Virginia State Dept. of Education. Available from http://eric.ed.gov/ERICDocs/data/ericdocs2/content_storage_01/0000000b/80/11/70/b0.pdf. [5-2]

Marcinek, A. (2011). Five steps for implementing a successful 1:1 environment. *Edutopia*. Available from http://www.edutopia.org/blog/1%3A1-environment-andrew-marcinek. [1]

Martin, W., Strother, S., Beglau, M., Bates, L., Reitzes, T., & Culp, K. M. (2010). Connecting instructional technology professional development to teacher and student outcomes. *Journal of Research on Technology in Education*, 43(1), 53-74. [6]

McHale, T. (2007). 1:1 in Texas. *Technology & Learning*, 4. Available from http://www.techlearning.com/showArticle.php?articleID=196604145. [5-2]

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Washington, DC: Department of Education, Office of Planning, Evaluation, and Policy Development. Available from http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf. [1]

Metis Associates. (1999). *Program evaluation: The New York City board of education community school district six laptop project*. Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Quebec. New York, NY: New York City Board of Education Community School District Six. [5-1a, 5-2]

MGT of America. (2000). *The rural connection: Evaluation report year one*. Florida Learning Alliance. Tallahassee, FL: MGT of America. [5-2]

MGT of America. (2001). *The rural connection: Evaluation report year two*. Florida Learning Alliance. Tallahassee, FL: MGT of America. [5-2]

Miranda, H., & Russell, M. (2011). Predictors of teacher-directed student use of technology in elementary classrooms: A multilevel SEM approach using data from the USEIT study. *Journal of Research on Technology in Education*, 43(4), 301-323. [6]

Mitchell Institute. (2004a). *1:1 laptops in a high school environment: Piscataquis Community High School study interim report*. Great Maine Schools Project. Mitchell Institute. [5-2]

Mitchell Institute. (2004b). *1:1 laptops in a high school environment: Piscataquis Community High School study final report.* Portland, ME: Great Maine Schools Project, George J. Mitchell Scholarship Research Institute. Available from http://www.greatschoolspartnership.org/pdf/1:1Computing_Report.pdf. **(**[5-1b, 5-2]

Monitoring and Evaluation Services, Alexandria City Public Schools. (2006). *Formative evaluation of the technology integration in 2004-05* (p. 135). Alexandria City, VA: Alexandria City Public Schools. [5-2]

Morrison, G., Ross, S. M., & Lowther, D. L. (2007). *Technology as a change agent in the classroom*. Presented at Voices of the Past-Visions of the future: Learning and Instructional Technologies for the 21st Century June 22-25, 2006 Bloomington, Indiana. Available from http://aect.org/events/symposia/Docs/Technology%20as%20a%20Change%20Agent.pdf. [5-2]

Mouza, C. (2006). *Learning with laptops: The impact of 1:1 computing on student attitudes and classroom perceptions*. ICLS '06 Proceedings of the 7th International Conference on Learning Sciences (pp. 488-494). Bloomington, Indiana: International Society of the Learning Sciences. [5-2]

Muir, M., Knezek, G., & Christensen, R. (2004). *The Maine learning technology initiative: An exploratory study of the impact of ubiquitous technology on student achievement*. Research Brief MLLS0401. Available from http://www.oberlin.k12.oh.us/onetoonedocs/Maineresearch.pdf. [1]

Myers, J. L. (1996). *The influence of a take-home computer program on mathematics achievement and attitudes of Title I elementary school children.* Unpublished doctoral dissertation. Athens, GA: University of Georgia. [5-1a]

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature review on mobile technologies and learning*. Bristol, UK: Futurelab. Available from www.futurelab.org.uk. [1]

Newhouse, C. P. (2001). A follow-up study of students using portable computers at a secondary school. *British Journal of Educational Technology, 32*(2), 209-219. [5-1b]

Newhouse, C. P., & Rennie, L. (2001). A longitudinal study of the use of student-owned portable computers in a secondary school. *Computers & Education, 36*(3), 223-243. [5-1b, 5-2]

Niles, R. (2006). *A study of the application of emerging technology: Teacher and student perceptions of the impact of 1:1 laptop computer access*. Unpublished doctoral dissertation. Wichita, KS: Wichita State University. Available from http://soar.wichita.edu:8080/dspace/bitstream/10057/373/6/d06005.pdf. [5-2]

O'Donnell, C. L. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention. *Review of Educational Research*, 78(1), 33-84. [1]

O'Donovan, E. (2009). Are 1:1 laptop programs worth the investment? *District Administration*, February 2009. Available from http://www.districtadministration.com/article/are-one-one-laptop-programs-worth-investment. [1]

Oliver, K. M., & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of 1:1 computing. *Educational Media International*, 45(3), 215–229. [5-3]

Olofsson, A. D., Lindberg, O., Fransson, G., & Hauge, T. E. (2011). Uptake and use of digital technologies in primary and secondary schools—a thematic review of research. *Nordic Journal of Digital Literacy*, 4, 207-225. [2]

One Child Per Laptop. (n.d.) Retrieved from http://one.laptop.org/ [7]

Owston, R., & Wideman, H. (2001). Computer access and student achievement in the early school years. *Journal of Computer Assisted Learning*, 17(4), 433-444. [5-2]

Parr, J. M., & Ward, L. (2011). The teacher's laptop as a hub for learning in the classroom. *Journal of Research on Technology in Education*, 44(1), 53-73. [1]

Pasnik, S., Penuel, W. R., Lorente, C., Strother, S., & Schindel, J. (2007). *Review of research on media and young children's literacy: Report to the Ready to Learn Initiative*. New York and Menlo Park, CA: Education Development Center, Inc., and SRI International. Available from http://cct.edc.org/rtl/index.asp. [3]

Pellegrino, J. W., & Quellmalz, E. S. (2010). Perspectives on the integration of technology and assessment. *Journal of Research on Technology in Education*, 43(2), 119-134. Available from http://blogs.ubc.ca/hoglund/files/2011/05/assessment2.pdf. [1]

Penuel, W. R. (2005). *Research: What it says about 1 to 1 learning*. Sponsored by Apple Computer, Inc. Available from http://ubiqcomputing.org/Apple_1-to-1_Research.pdf. [4]

Penuel, W. R. (2006). Implementation and effects of 1:1 computing initiatives: A research synthesis. *Journal of Research on Technology in Education*, 38(3), 329-349. [7] (Re-published version of Penuel, 2005)

Penuel, W. R., Kim, D. Y., Michalchik, V., Lewis, S., Means, B., Murphy, B., et al. (2002). *Using technology to enhance connections between home and school: A research synthesis*. Menlo Park, CA: SRI International. Available from http://ctl.sri.com/publications/downloads/Task1_FinalReport3.pdf. [4]

Prensky, M. (2008). *The role of technology in teaching and the classroom*. Available from http://www.marcprensky.com/writing/Prensky-The_Role_of_Technology-ET-11-12-08.pdf. [1]

Prensky, M. (2009). *Teaching digital natives: Partnering for real learning*. Thousand Oaks, CA: Corwin Press. Pre-publication draft available from http://oetmanhattan.wikispaces.com/file/view/Prensky--Teaching+Digital+Natives-in+press6.pdf. [1]

Price, J. K., & Roth, M. (2009*). Evaluating effective teaching and learning within complex levels of interaction*. Santa Clara, CA: Intel Corporation. Available from http://www.intel.com/about/corporateresponsibility/education/programs/evaluations/index.htm?wapkw=(Evaluating+Effective+Teaching+and+Learning+within+Complex). [2]

Project Tomorrow (2011). *Speak Up 2010 national findings*. Irvine, CA: Author. Available from http://www.tomorrow.org/speakup/pdfs/SU10_3EofEducation_Students.pdf. [1]

Project Red: Revolutionizing Education. (2009). Retrieved from http://www.projectred.org/[7]

Quellmalz, E. S., & Pellegrino, J. W. (2009). Technology and testing. *Science*, 323, 75-79. [1]

Rideout, D. (2002). Laptops on the Range. *Education Canada*, 42(2). [2]

Rockman et al. (1995). *Assessing the growth: The Buddy Project evaluation, 1994-5.* San Francisco: Author. Available at http://www.rockman.com/projects/125.cet.buddy/bud95final.pdf. [5-1a]

Rockman et al. (1998). *Powerful tools for schooling: Second year study of the laptop program.* San Francisco: Author. [5-1a]

Rockman et al. (2000). *A more complex picture: Laptop use and impact in the context of changing home and school access.* San Francisco: Author. Available from http://www.rockman.com/projects/126.micro.aal/yr3_report.pdf. [5-1a]

Rockman, S. (2003). Learning from laptops. *Threshold*, Fall 2003, 24-28. Available from http://rockman.com/articles/learningfromlaptops.pdf. [1]

Rockman et. al. (2004). *Kamehameha schools Maui laptop project: Findings from classroom observations and teacher interviews*. San Francisco, CA: Rockman et. al. Available from http://www.rockman.com/projects/129.pase.maui/maui_laptop1_final.pdf. [5-2]

Rockman, S. (2007). It's my laptop. *Threshold*, Winter 2007, 21-25. Available from http://rockman.com/publications/articles/ItsMyLaptop.pdf. [1]

Rockman et al. (2012). Retrieved from http://www.rockman.com/ [7]

Ross, S. M., Lowther, D. L., & Morrison, G. R. (2001). *Anytime, anywhere learning: Final evaluation report of the laptop program: Year 2*. Memphis, TN: University of Memphis. Available from http://www.walledlake.k12.mi.us/aal/Research/Eval_Year_2.pdf. [5-2]

Ross, S. M., Morrison, G. R., Lowther, D. L., & Plants, R. (2000). *Anytime, anywhere learning final evaluation report of the laptop program: Year one*. Memphis, TN: University of Memphis. [5-2]

Ross, S. M., Lowther, D. L., Wilson-Relyea, B., Wang, W., & Morrison, G. R. (2003). *Anytime, anywhere learning final evaluation report of the laptop program: Year 3*. Memphis, TN: The University of Memphis. Available from http://www.walledlake.k12.mi.us/aal/Research/Laptop_Report_Yr3.pdf. [5-2]

Russell, M., & Higgins, J. (2003). *Assessing effects of technology on learning: Limitations of today's standardized tests*. Boston, MA: Technology and Assessment Study Collaborative, Boston College. Available from http://www.ncat.edu/~esterlin/FacultyForum/Readings/viewcontent.pdf. [1]

Russell, M., Bebell, D., & Higgins, J. (2004). *Laptop learning: A comparison of teaching and learning in upper elementary classrooms equipped with shared carts of laptops and permanent 1:1 laptops.* Boston: Technology and Assessment Study Collaborative, Boston College. Available from http://escholarship.bc.edu/intasc/1. [5-1b, 5-2]

Salerno, M.A., & Vonhof, M. (2011). Launching an iPad program: A primer. *T.H.E. Journal*, December 14, 2011. Available from http://thejournal.com/articles/2011/12/14/launching-an-ipad-1-to-1-program-a-primer.aspx. [1]

Sargent, K. (2003a). *The Maine Learning Technology Initiative: What is the impact on teacher beliefs and instructional practices? Occasional Paper# 3*. University of Southern Maine: Center for Education Policy, Applied Research and Evaluation. Available from http://usm.maine.edu/sites/default/files/Center%20for%20Education%20Policy,%20Applied%20Research,%20and%20Evaluation/MLTI_Impact_Teacher_Beliefs.pdf. [5-2]

Schaumburg, H. (2001a). *Fostering girls' computer literacy through laptop learning.* Paper presented at the National Educational Computing Conference, Chicago, IL. [5-1a, 5-1b]

Schaumburg, H. (2001b). *The impact of mobile computers in the classroom–Results from an ongoing video study*. Paper Presented at the 24th National Convention of the Association for Educational Communications and Technology (Atlanta, GA, November 8-12, 2001). Available from http://www.eric.ed.gov/PDFS/ED470113.pdf. [5-2]

Schieber, C. E. (1999). *Information technology and education: An evaluation of a school laptop computer program.* Unpublished doctoral dissertation. Seattle, WA: Seattle Pacific University. [5-1a]

Schmid, R. F., Miodrag, N., & Di Francesco, N. (2008). Human-computer partnership: The tutor/child/computer triangle promoting the acquisition of early literacy skills. *Journal of Research on Technology in Education*, 41(1), 63-84). [1]

Sclater, J., Sicoly, F., Abrami, P. C., & Wade, A. C. (2006). Ubiquitous technology integration in Canadian public schools: Year one study. *Canadian Journal of Learning and Technology*, 32(1). Available from http://www.cjlt.ca/content/vol32.1/sclater.html. [5-2, 5-3]

Sclater, J., Sicoly, F., Grenier, A., Abrami, P. C., & Wade, C. A. (2005). *ETSB-CSLP laptop research partnership school net report: Preliminary study*. Montreal, QC: Centre for the Study for Learning and Performance. Available from http://doe.concordia.ca/cslp/Downloads/PDF/ETSB_final_report_0628.pdf. [5-2]

Selwyn, N. (2007). *Web 2.0 applications as alternative environments for informal learning—a critical review*. Paper presented at the OECD-KERIS International Expert Meeting on ICT and Educational Performance, Cheju Island, South Korea. Available from http://www.oecd.org/dataoecd/32/3/39458556.pdf. [1]

Shachar, M., & Neumann, Y. (2010). *Twenty years of research on the academic performance differences between traditional and distance learning: Summative meta-analysis and trend examination. MERLOT Journal of Online Learning and Teaching*, 6(2), 334. Available from http://significantfederation.com/eblast/2010.06.21/landing/20_Years_of_Research_Differences_Between_Traditional_and_Distance_Learning.pdf. [1]

Shakeshaft, C., Mann, D., & Becker, J. (1999). *Lightspan achieve now! Documenting the second year of educational achievement and program effects in the schools of the Adams County School District.* 50, Westminster, Colorado. Huntington, NY: Interactive, Inc. [5-1a]

Shapley, K.S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *Journal of Technology, Learning, and Assessment*, *9*(4). Available from: www.jtla.org. [6]

Shapley, K. S., Sheehan, D., Sturges, K., Caranikas-Walker, F., Huntsberger, B., & Maloney, C. (2006). *Effects of technology immersion on teaching and learning: Evidence from observations of sixth-grade classrooms*. Austin, TX: Texas Center for Educational Research. Available from http://www.tcer.org/research/etxtip/documents/classroom_observation.pdf. [1]

Shapley, K., Sheehan, D., Sturges, K., Caranikas-Walker, F., Huntsberger, B., & Maloney, C. (2006a). *Evaluation of the Texas Technology Immersion Pilot: First year results*. Austin, TX: Texas Center for Educational Research. Available from http://www.tcer.org/research/etxtip/documents/01e_txtip_first_yr_report.pdf. [5-2]

Shapley, K., Sheehan, D., Sturges, K., Caranikas-Walker, F., Huntsberger, B., & Maloney, C. (2006b). *Effects of technology immersion on teaching and learning: Evidence from observations of sixth-grade classrooms.* Austin, TX: Texas Center for Educational Research. Available from http://www.tcer.org/research/etxtip/documents/classroom_observation.pdf. [5-2]

Shrout, S., Munoz, M. A., & O'Daniel, S. (2005). *Computer laptops assisting in student success - project 1stClass: Year 1 evaluation*. Jefferson County, FL: Department of Accountability, Research and Planning, Jefferson County Public Schools. Available from http://www.eric.ed.gov/PDFS/ED504260.pdf. [5-2]

Siegle, D., & Foster, T. (2000, April). *Effects of laptop computers with multimedia and presentation software on student achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. [5-1a]

Silvernail, D. L. (2009). *Research and evaluation of the Maine Learning Technology Initiative (MLTI) laptop program: Inputs on student achievement*. Available from http://maine.gov/mlti/resources/MLTI_March_09.pdf. [6]

Silvernail, D. L., & Harris, W. J. (2003). *The Maine Learning Technology Initiative teacher, student, and school perspectives: Mid-year evaluation report.* Portland, ME: Maine Education Policy Research Institute, University of Southern Maine. Available from http://www.bryan.k12.oh.us/Forms/Maine%20MidYear%20.pdf. [5-1b, 5-2]

Silvernail, D., & Lane, D. (2004). *The impact of Maine's 1:1 laptop program on middle school teachers and students: Phase one summary evidence.* Portland, ME: Maine Education Policy Research Institute, University of Southern Maine. Available from http://www.bryan.k12.oh.us/Forms/MLTIPhaseOne.pdf. [5-1b, 5-2]

Silvernail, D., Pinkham, C. A., Winle, S. E., Walker, L. C., & Bartlett, C. L. (2011). *A middle school 1:1 laptop program: The Maine experience*. Gorham, ME: Maine Education Policy Research Institute, University of Southern Maine. Available from http://usm.maine.edu/sites/default/files/Center%20for%20Education%20Policy,%20Applied%20Research,%20and%20Evaluation/MLTIBrief20119_14.pdf. [6]

Stallings, T., Corn, J. O., & Kleiman, G. (2010*). K-12 technology usage status report: NC school connectivity initiative initial evaluation*. Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University. Available from http://www.fi.ncsu.edu/assets/research_papers/evaluation-of-the-school-connectivity-initiative/k-12-technology-usage-status-report-nc-school-connectivity-initiative-initial-evaluation-.pdf. [6]

State Educational Technology Directors Association. (2008). Retrieved from http://setda.org/ [7]

State of New South Wales, Department of Education and Training (2009). *1:1 computing: Literature review*. Available from https://www.det.nsw.edu.au/media/downloads/about-us/how-we-operate/national-partnerships-program/digital-education-revolution-nsw/rrql/research/lit_review.pdf. [2]

State of New South Wales, Department of Education and Training (2010). *1:1 computers in schools: 2010 literature review*. Available from http://www.projectred.org/uploads/lit_review10_TrMbcLRPRT.pdf. [2]

Stevenson, K. R. (1998). *Evaluation report - Year 2: Middle school laptop program, Beaufort County School District.* Beaufort, SC: Beaufort County School District. [5-1a]

Stevenson, K. R. (1999). *Evaluation report - Year 3: Middle school laptop program, Beaufort County School District.* Beaufort, SC: Beaufort County School District. [5-1a, 5-2]

Stevenson, K. R. (2001). *Evaluation report: High school laptop computer program* (School year 2000/2001). Evaluation, Liverpool: New York: Liverpool Central School District. [5-2]

Stevenson, K. R. (2002). *Evaluation report - Year 2: High school laptop computer program* (Final Report, for school year 2001/2002). Liverpool: Liverpool Central School District, New York. [5-1b, 5-2]

Stevenson, K. R. (2004). *Evaluation report-Year 3: High school laptop computer program* (Final Report, for school year 2002/2003). Evaluation, Liverpool: New York: Liverpool Central School District. [5-2]

Strudler, N. (2010). Perspectives on technology and educational change. J*ournal of Research on Technology in Education*, 42(3), 221-229. Available from http://coe.nevada.edu/nstrudler/Strudler_2010.pdf. [1]

Suhr, K.A., Hernandez, D.A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth-grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology, Learning, and Assessment, 9*(5). Available from http://www.jtla.org. [1]

Swan, K., Kratcoski, A., Mazzer, P., & Schenker, J. (2005). Bringing Mohamed to the mountain: Situated professional development in a ubiquitous computing classroom. *Journal of Educational Computing Research*, 32(4), 353–365. [5-3]

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research*, 81(1), 4-28. [3]

Tech & Learning. (2012). Retrieved from http://www.techandlearning.com/index/ [7]

Texas Education Agency. (2001). *Report on the Ed Tech PILOTS.* Austin: Texas Education Agency. [5-1b]

Towndrow, P. A., & Vaish, V. (2009). Wireless laptops in English classrooms: A SWOT analysis from Singapore. *Educational Media International*, 46(3), 207–221. [5-3]

Trimmel, M., & Bachmann, J. (2004). Cognitive, social, motivational and health aspects of students in laptop classrooms. *Journal of Computer Assisted Learning, 20*(2), 151-158. [5-1b, 5-2]

Trucano, M. (2005). *Knowledge maps: ICTs in education*. Washington, DC: infoDev. Available from http://www.ictliteracy.info/rf.pdf/KnowledgeMaps_ICTs_and_the_Education_MDGs.pdf. [1]

U.S. Department of Education, Office of Educational Technology (2010). T*ransforming American education: Learning powered by technology*. Washington, DC: U. S. Department of Education. Available from http://www2.ed.gov/about/offices/list/os/technology/netp.pdf. [2]

Ubiquitous Computing Evaluation Consortium. (2003). Retrieved from http://www.ubiqcomputing.org/lit_review.html/ [7]

University of Michigan (2007). *Research summaries: Freedom to learn project*. [2]

Walker, L., & Rockman, S. (1997). Report of a Laptop Program Pilot: A Project for Anytime Anywhere Learning by Microsoft Corporation, Notebooks for Schools by Toshiba America Information Systems. Evaluation, San Francisco, CA: Rockmann et. al. [5-2]

Walker, L., Rockman, S., & Chessler, M. (2000). A More Complex Picture: Laptop Use and Impact in the Context of Changing Home and School Access (Third in a Series of Research Studies on Microsoft's Anytime Anywhere Learning Program). Evaluation, San Francisco, CA: Rockman et. al. [5-2]

Ware, P. D., & Warschauer, M. (2005). Hybrid literacy texts and practices in technology-intensive environments. *International Journal of Educational Research*, 43, 432–445. [5-3]

Warschauer, M. (2007). Information literacy in the laptop classroom. *Teachers College Record*, 109(11), 2511–2540. [5-3]

Warschauer, M. (2010). Digital divide. *Encyclopedia of Library and Information Sciences*, Third Edition, 1: 1, 1551 — 1556. Available from http://gse.uci.edu/person/warschauer_m/docs/digitaldivide.pdf. [1]

Warschauer, M., & Ames, M. (2010). Can one laptop per child save the world's poor? *Journal of International Affairs*, 64(1), 33-51. [1]

Warschauer, M., & Grimes, D. (2005). First Year Evaluation Report: Fullerton School district Laptop Program. Evaluation, Orange County, CA: Fullerton School District. Retrieved March 27, 2007, from http://www.fsd.k12.ca.us/menus/1to1/evaluation/FSD-laptop-year1-eval.pdf. [5-2]

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education*, 434, 179-225. [2]

Warschauer, M., Grant, D., Real, G. D., & Rousseau, M. (2004). Promoting academic literacy with technology: Successful laptop programs in K-12 schools. *System, 32*(14), 525-538. [5-1b, 5-2]

Weston, M. E., & Bain, A. (2010). The end of techno-critique: The naked truth about 1:1 laptop initiatives and educational change. *Journal of Technology, Learning, and Assessment*, 9(6). Available from http://www.jtla.org. [2, 7]

Wilson, L., & Gielniak, M. (2011). *Technology for learning: A guidebook for change*. Available from http://reg.accelacomm.com/servlet/Frs.FrsGetContent?id=80601784. [2]

Windschitl, M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal, 39*(1), 165-205. [5-1b]

Woolf, B. P (2010). *A roadmap for education technology*. Washington, DC: National Science Foundation. Available from http://www.cra.org/ccc/docs/groe/GROE%20Roadmap%20for%20Education%20Technology%20Final%20Report.pdf. [2]

World Bank (2011). Can computers help students learn? *From Evidence to Policy*, No. 4. Available from http://siteresources.worldbank.org/EXTHDOFFICE/Resources/5485726-1288802844934/Brochure-correct-4.pdf. [1]

Yan, B., & Codde, J. (2005). Technology adoption in 1:1 laptop computer environment: A case study. Available from https://www.msu.edu/~boyan/doc/onetoone.pdf. [5-2]

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Available from http://ies.ed.gov/ncee/edlabs/regions/southwest/pdf/rel_2007033.pdf. [1]

Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research, 30*, 371-388. [7]

Zucker, A.A., (2005). Starting school laptop programs: Lessons learned. Policy Brief, Number 1. Available from http://www.genevalogic.com/blog/wp-content/uploads/2006/08/Lessons_Learned_Brief.pdf. [2]

Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a 1:1 laptop school. *Journal of Science Education and Technology*, 17(6), 586–594. [5-3]

Zucker, A. A., & Light, D. (2009). Laptop programs for students. *Science*, 323 (5910), 82-85. [2, 7]

Zucker, A. A., & McGhee, R. (2005). *A study of 1:1 computer use in mathematics and science instruction at the secondary level in Henrico County Public Schools.* Arlington, VA: SRI International. Available from http://ubiqcomputing.org/FinalReport.pdf. [5-1b]