Research Report for GeSCI Meta-Review of ICT in Education

In response to:

Terms of Reference for
GeSCI Request for Proposal
Meta-review of ICT in Education Research

(TOR dated 17 February, 2009)

Prepared by:

John LeBaron
Jay M. Robinson Distinguished Professor of Educational Technologies
Western Carolina University
University of North Carolina
Cullowhee, NC, USA

Elizabeth McDonough
Education Reference Librarian
Western Carolina University
University of North Carolina
Cullowhee, NC, USA

April 13, 2009
(Revised April 17, 2009)

Table of Contents

Page

Discussion of Search Procedures and Challenges Related to GeSCI Study

Overview

The purpose of this research is to provide a multi-disciplinary, multi-methodological lens for understanding the complexity and exponential growth of ICT around the world. The scope was limited to studies conducted between 2006 and 2008, and included articles from traditional peer-reviewed literature and "grey literature," such as policy reports, conference papers, and reports from the popular media. Although the scope of the search was limited to five thematic streams outlined in GeSCI's Terms of Reference, the comprehensive nature of those themes dictated a search methodology that was both focused and far-reaching.

Search Methodology

Given the prolific nature of the academic publishing environment in the digital age and the time constraints of this project, the scope of this review is limited. A search of the Educational Resources Information Center (ERIC), the world's largest index of educational research revealed more than 14,000 research reports related to technology indexed over the two years targeted by this review. Despite its size, ERIC cannot be considered a fully comprehensive index of all educational research. Thus, a fully exhaustive review would have involved a larger number, though not necessarily a better quality, of studies. Fortunately, ERIC provides an excellent cross-section of studies that are meticulously organized and indexed. It offers access to the bibliographic records of nearly 900 journals, most of which are peer-reviewed, and more than 700 non-journal sources. Despite the fact that is a database maintained by the United States Government, the collection is international in scope, as indicated by the results of this research.

Given the significant challenges presented, the researchers sought a systematic review of the literature that would reveal the general trends in ICT research as it related to the articulated themes. In this case, ERIC was a particularly good tool because of its use of controlled vocabulary. Even with the rise in popularity and ease of use of keywords, a serious methodical review of the research, particularly in a vast area, such as ICT inquiry, is well served by structured indexing according to a controlled vocabulary. The identification and use of assigned subject descriptors (see Appendix A), allowed the researchers to conduct the search with confidence that major trends in specific areas could be uncovered and reviewed. ERIC also allowed the researchers to narrow the publication type to research reports, which included descriptive, evaluative, general and empirical categories. With minor exceptions, the scope of this research was further limited to pre-K through secondary education. A few studies on higher education related to teacher education, however, were included.

In certain cases, particular issues were vetted with the supplemental use of Google Scholar, which uses Google's familiar search algorithms to facilitate intuitive, broad searches of scholarly sources. Each approach has strengths and weaknesses, but they complement each other appropriately. The evolving educational jargon commonly used to describe concepts, particularly concepts related to educational technology, generates appreciation on the part of the researcher for the opportunity to use multiple tools and approaches to study the issues at hand.

While ERIC and Google Scholar were used to pinpoint the bibliographic information for each study, the full-text content was acquired from a wide array of sources. The researchers were able to track open-access sources for 61 of the studies reviewed. The remaining 183 studies were accessible only by subscription or individual purchase. The researchers were able to obtain access to most these studies through library subscriptions to journals and databases, and some use of interlibrary loan. For the purposes of this project, 244 studies were identified and reviewed. The bibliographic information for each study was archived in the database map, including open access URLs when they were available.

While not exhaustive, the researchers are confident that this literature survey reveals the major topics of academic dialogue and methodological approaches underlying ICT research in the years specified in GeSci's Terms of Reference. Phase One of this meta-review project has indeed provided a pool of studies from which an overview of the meaning of the research has been derived, but it is evident that deeper investigation into any of the issues outlined by GeSci's themes might continue to provide even greater meaning from the existing literature, which in and of itself is experiencing exponential growth.

Anomalies

Investigation of the literature on GeSci's thematic framework produced findings that cross the five discussion categories. In some cases, therefore, citations may appear in more than one report section under different names. An investigation of specific documents suggested to the researchers that some studies better fit certain themes than those generated by the search terms used. Thus, each theme-by-theme narrative carries its own reference list that may not precisely match the references produced by the controlled vocabulary search. In the narrative, certain references were not cited because their content was deemed to be of marginal quality or relevance. These decisions reflect the professional judgment of the researchers. On the contrary, a small number of references from outside the controlled vocabulary search were included because the researchers judged them to inform the overall narrative. The comprehensive Excel database provided in a separate file contains the complete pathways to the literature generated by the controlled vocabulary search.

Organization of this document

Following this section of the narrative, the report is organized by the five following themes specified in the GeSci Terms of Reference. (Each narrative section was written to stand on its own.)

1. Educational ICT leadership and management
2. ICT infrastructure, connectivity and accessibility
3. Integration of ICTs into teaching and learning
4. Teacher education and ICT
5. Educational Content and ICT

The narrative discussion of each theme is further sub-divided under the following headings:

a. Overview
b. Challenges and constraints impacting progress

c. Evolving approaches in the field
d. "Hot" topics
e. Research gaps suggesting further investigation
f. References

The main narrative of this report is followed by an appendix indicating the search terminology used for each of the themes investigated, and by an alphabetized list of references produced by the controlled vocabulary investigations.

The researchers look forward to a conversation with the principals at GeSci with a view to determining the emphases required for Phase Two of this project.

John LeBaron
Jay M. Robinson Distinguished Professor of Educational Technologies
Western Carolina University
University of North Carolina
Cullowhee, NC, USA

Elizabeth McDonough
Education Reference Librarian
Western Carolina University
University of North Carolina
Cullowhee, NC, USA

April 12, 2009

Educational ICT Leadership and Management

Overview

The overall leadership challenges of ICT integration in schools and universities may be symbolized by the rapidly-emerging delivery of fully online courses to secondary school students in many countries. Huett, Moller, Foshay and Coleman (2008) decry the lack of expert instructional design behind the distribution of online courses to secondary schools. Holstead, Spradley and Plucker (2008) challenge the emerging focus of online learning to American schools, suggesting that insufficient attention has been paid to such concerns as accountability, standards, instructional quality, and teacher preparation.

The section will address questions of educational leadership, management, and policy for ITC integration in education. It will include such concerns as institutional roles, cost-benefits analysis, training and professional development, access equity, and professional roles.

Challenges and constraints impacting progress

What school conditions should educational leaders sustain in order to assure the efficacy of ICT development, and what are the barriers to realizing those conditions? In an international study, Hew and Brush (2007) pinpoint the following implementation obstacles:

- teacher and administrator attitudes and beliefs
- ineffective leadership strategies
- insufficient resources applied to ICT
- insensitivity to local cultures
- constraints of traditional institutional structure

To this run-down of obstacles to ICT implementation, Williams, Atkinson, Cate, and O'Hair (2008) add the factors of teacher isolation and rigid hierarchical school organization. According to these researchers, one viable strategy to ameliorate these deficiencies is to promote the use of networked computing among teachers in order to reduce their chronic professional isolation. Such routines would encourage teachers to model practices, through their own professional behavior, that would extend toward more fully engaged student learning in schools.

Although the contemporary literature reveals agreement and discord about barriers to effective ICT integration in schools, the following sense seems to reassert itself from several sources:

- ICT investment among agencies and the levels of government are poorly coordinated.
- Spending on technology is insufficiently systemic and inappropriately targeted.
- Educational leaders are poorly trained either in general principles of effective leadership or in the particular application of leadership to ICT.
- Classroom teachers are poorly prepared to integrate ICT effectively or collaboratively.
- ICTs themselves are not employed to train educators about ICT.
- ICT investments are made in schools that are not structured in a way that capitalizes on their benefits.

- Research models to assess the efficacy of ICT implementation are inadequate to the problems addressed.

We shall address these and other related issues of leadership more fully in the following section.

Evolving approaches in the field

Several studies address the challenge of organizational coordination to support ICT sustenance in schools. Aczel et al. (2008), for example, have called for service-providing agencies to coordinate efforts in order to reduce the developmental overlaps and duplication of effort. They are concerned that organizational roles be appropriately matched to local needs and cultures, suggesting that such coordination is especially critical in developing countries.

In a recent book, Bramble and Panda (2008) urge cross-organizational coordination in planning the management of online, distance learning initiatives. From the United Kingdom, Sarah Younie (2006) offers an analytical review of the relationship between national ICT policy and local classroom implementation. She believes that the connection between the two tends to be tenuous, resulting from a failure to grasp the complexity of national policy implementation across a diverse patchwork of locally-administered schools. Stronger leadership at both levels is needed to counter a prevailing "if we regulate, they will implement" frame of mind.

A 2008 study by the Center for Digital Education in the USA stresses the importance of state-level policy to promote online "virtual secondary schooling" as a means to enrich the teaching talent pool, especially in geographically-remote areas and poorly-served school communities. Supporting this viewpoint, Lesisko and Wright (2007) suggest that school-level ICT staffing practices should align with state-level policy on ICT certification mandates. Addressing the reality of local-to-national policy alignment in the United Kingdom, Mee (2007) discusses what she views as a counterproductive conflict between centralized national ICT leadership and localized curriculum development.

Reporting from South Africa, Evoh (2007) suggests that ICT ranks among the most powerful educational reform tools available to achieve the "Education for All" goals of the United Nations. Because of severe resource constraints, especially in developing countries, Evoh advocates for close program collaboration across government entities, the private sector, and local schools. Chadwick and Valenzuela (2007) urge program developers to account for unique regional cultural attributes in educational ICT development.

How can leadership best be applied to ensure the most effective advancement possible for the productive use of ICTs in schools? Notwithstanding the advocacy already mentioned for cross-level organizational cooperation, several studies suggest that the nexus of responsibility rests with the local school principal (head). This tenet appears to apply regardless of the nation studied. From Iran, Ashfari et al. (2008) affirm that the most critical agent for technological transformation in the school curriculum is the local school principal. He suggests that school heads possess a greater need for training in transformational leadership than for management and technology. Observers from other countries reinforce this viewpoint, for example:

- Coca and Allensworth (2007), USA

- Chang, Chin and Hsu (2008), Taiwan
- Haughey (2006), Canada

According to Wong (2006), school principals needed better to inform themselves of their teachers' perceptions. Based on a survey of Hong Kong primary school headmasters and teachers, heads appear to be significantly more sanguine about the success of ICT integration than the teachers working under their supervision. Educational leaders should take this divergence of view into account when developing and resourcing curriculum projects.

In view of the foregoing, how are educational leaders trained for effective leadership? Klein (2008) offers the case study of a California school that has successfully employed networked ICT tools in order to advance professional skills and promote collaborative program-sharing. Harris (2008) outlines a series of principles for the effective pursuit of educational technology professional development (ETPD). Harris asserts that professional development must be carefully matched to the larger purposes of ICT implementation. This train of thought is supported by Wasonga (2007) who believes that the professional development of educational leaders should be supported by a thorough analysis of ICT impact on curriculum.

Regardless of the most appropriate venue for leadership, several studies examine the image of ICT implementation in schools. The picture is mixed. Based on a self-reporting survey of teachers in two suburban Texas elementary schools, current ICT practice poorly serves contemporary student learning needs. Despite state-level prescriptions for technology integration across the curriculum, very little innovative practice seems to be filtering down to local classrooms. This finding is reflected in Brazil where de Fatima (2007) suggests that creative implementation has been hampered by poor decisions about the local deployment of ICT resources. She worries about insufficient attention to measures, such as ongoing professional development, that would sustain the beneficial effects of initial technology investments.

From a multinational perspective, Juang, Liu and Chan (2008) advocate for systemic and collaborative school-wide ICT curriculum integration that involves multiple stakeholders at all stages of development. According to these observers, isolated, individually-driven initiatives typically fail to produce lasting change. They advocate a developmental model that they call 3-C (creation, collaboration and communication) for long-term ICT integration.

Assessing the benefits of ICT investment against its substantial costs has proven to be a challenge. McDougall and Jones (2006) argue against the over-emphasis on quantitative cost-benefits analyses of ICT implementation, preferring instead greater stress on qualitative studies, based on research and learning theory, teaching methodology and student activity. Again, we are guided by findings from different countries. In Turkey, Gulbakar (2007) reports that massive educational technology investments have produced little evidence of success, resulting from a lack of planning especially at local levels. He discovered that, although school teachers and administrators feel technically competent with ICT tools, neither group expresses satisfaction about the efficacy of curricular integration.

In America, Kaestner (2007) avows that credible measures for calculating costs and assessing benefits of ICT are yet to be developed. He claims that typical business models for such

assessment are inadequate to the needs of education. Leonard and Leonard (2006) seem to agree. In the state of Louisiana, curricular ICT integration is not reflecting the large-scale investments made. They opine that educational leaders, especially school administrators, are poorly equipped and trained not only to lead to ICT integration but also to assess its costs and benefits.

From Bangladesh, Akhtar (2008) stresses the importance of effective measurement for quality assurance in the design and distribution of open and flexible online courses to higher education students in that country. The goal of such assessment is to assure equivalency of quality between online and classroom-based educational delivery. Other researchers have expressed doubt that this is the right question to ask. Kember (2007) cautions that online educational program development should take care to distinguish between the principles that would apply to higher education versus those that pertain to elementary and secondary schools.

Gulati (2008) questions the massive investment in Internet-based ICT in developing countries, especially considering the high, concomitant investment requirements in such areas as infrastructure, teacher training, and curriculum development. As for the educational opportunity created by ICT investment, Gulati suggests that the track record has been poor -- and poorer still for the most indigent sub-populations within these countries. Remedies are hard to find, but unless a broad range of investments is coordinated in a manner that responds to regional cultural realities, narrowly focused spending will fail to produce desired results. Extending this argument in a Brazilian context, Amiel (2006) distinguishes between one-time capital investment in broad-scale computer distribution and the more transformational infusion of ICT for long-term pedagogical change. He argues that the distribution of material can "add value" only if accompanied by sustained leadership at all levels of the educational hierarchy.

Becker (2006) claims that ICT investment across 40 American states has failed to solve the digital divide of access, especially in rural schools and those that serve relatively large populations of Afro-Americans. Becker's research also suggests that the educational use of computers is optimized when they are available in classrooms as opposed to being clustered in labs. In accord with Lesisko and Wright (2007), he emphasizes the importance of state-level technology-specific credentialing to effective classroom integration. States without it seemed not to perform as well as states with it.

How can we know that ICT investments actually work? Sawtelle (2008) and Tompsett (2007) acknowledge the complexity of such analysis. Sawtelle urges the development of improved empirical research models to build a deeper, more credible knowledge base. In considering the efficacy of curricular ICT, Serim (2007) suggests that research on educational outcomes should be grounded in knowledge about curriculum and pedagogy rather than relying on commercial models of inquiry. Tompsett believes that efficacy research in educational technology should draw upon the more general traditions of scholarship in education. Doing so, she asserts, will render the technology-centered research more credible.

In another study, Zucker et al. (2008) report on the results of several years' implementation of a US based project called Technology-Enhanced Elementary and Middle School Science project (TEEMSS II). TEEMSS promotes the use of computerized science probes and virtual laboratories to simulate science lab situations in grades 3 through 8. Research on this project

compared science learning outcomes between classrooms that used TEEMSS resources and strategies with classrooms that did not. Results favored the former. Less favorable results were found in a project that promoted the use of personal digital assistants (PDAs) to support training teachers in modern foreign languages (Wishart, 2008). In this project, seven student teachers were loaned PDAs for the duration of a training course. Course interviews revealed that the subjects preferred more traditional technology tools such as desktop and laptop computers.

"Hot" topics in this field

The following broad topics emerge from this preliminary thematic review:

1. How are ICT policies and program developments best coordinated across different kinds and levels of agency?
2. Where might the loci of effective leadership at various levels of ICT implementation be found?
3. What local conditions in schools promote sustainable ICT development?
4. How do we know that ICT implementation is working as intended?
5. How is equitable access to ICT resources created and sustained?
6. How do we assess the efficacy of ICT investment cost?
7. In assessing ICT efficacy, what questions should we be asking?
8. What role does culture play in the successful implementation of ICT?

Research gaps suggesting further investigation

According to Palozzi (2006), the current baseline of empirical research on ICT efficacy is quite limited. Palozzi acknowledges the challenges of such research. It is not only difficult to control variables, but also it is almost impossible to maintain experimental purity in the real-world messiness of school classrooms. Conducting field-based research among children in schools raises legitimate ethical challenges that nonetheless create barriers to data gathering.

Cost effectiveness studies on the efficacy of ICT implementation in schools leaves many questions unanswered. For example, available research typically fails to address the quality of implementation. Costs may be assessed against goals and objectives that were not appropriate to the kinds of investment made. Original investments may have lacked components essential for success (such as professional development for teachers).

In recent years, research and action about strategies for infusing ICT in the school curriculum have shifted from transmissive models of curricular improvement to transformational strategies where ICT promotes the fundamental restructuring of teaching and learning. In view of this shift, Watson (2006) urges the refocusing of research on organizational development and on learning theory related to the student construction of knowledge.

References

Aczel, J. C., Peake, S. R., & Hardy, P. (2008). Designing capacity-building in E-learning expertise: Challenges and strategies. *Computers & Education, 50*(2), 499-510.

Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2008). School leadership and information communication technology. *Turkish Online Journal of Educational Technology, 7*(4)

Akhter, Z. (2008). Quality assurance in secondary education program of Bangladesh Open University: Present status and challenges. *Online Submission.*

Amiel, T. (2006). Mistaking computers for technology: Technology literacy and the digital divide. *AACE Journal, 14*(3), 235-256.

Becker, J. D. (2006). Digital equity in education: A multilevel examination of differences in and relationships between computer access, computer use and state-level technology policies. *Education Policy Analysis Archives, 15*(3), 1-38.

Bramble, W. J., & Panda, S. K. (2008). *Economics of distance and online learning: Theory, practice, and research.* New York: Routledge.

Center for Distance Education (2008). *Online learning policy and practice survey: A survey of the states.* Center for Digital Education.

Chadwick, C., & Valenzuela, S. (2008). Culture, change, and educational improvement. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 48*(4), 27-36.

Chang, I., Chin, J. M., & Hsu, C. (2008). Teachers' perceptions of the dimensions and implementation of technology leadership of principals in Taiwanese elementary schools. *Educational Technology & Society, 11*(4), 229-245.

Coca, V., Allensworth, E. M., & Consortium on Chicago, S. R. (2007). *Trends in access to computing technology and its use in Chicago public schools, 2001-2005.* Consortium on Chicago School Research.

de Fatima, D. & Alves, L. A. (2007). The implementation and use of computers in education in Brazil: Niteroi City/Rio de Janeiro. *Computers & Education, 49*(4), 1378-1386.

Evoh, C. J. (2007). Collaborative partnerships and the transformation of secondary education through ICTs in South Africa. *Educational Media International, 44*(2), 81-98.

Fletcher, D. (2006). Technology integration: Do they or don't they? A self-report survey from PreK through 5th grade professional educators. *AACE Journal, 14*(3), 207-219.

Gentry, L., Denton, C., & Kurz, T. (2008, July 1). Technologically-based mentoring provided to teachers: A synthesis of the literature. *Journal of Technology and Teacher Education, 16*(3), 339-373.

Gulati, S. (2008). Technology-enhanced learning in developing nations: A review. *International Review of Research in Open and Distance Learning, 9*(1), 1-16.

Gülbahar, Y. (2007). Technology planning: A roadmap to successful technology integration in schools. *Computers & Education, 49*(4), 943-956.

Harris, J. (2008). One size doesn't fit all: Customizing educational technology professional development -- Part Four -- evaluating ETPD designs. *Learning & Leading with Technology, 35*(8), 24-27.

Haughey, M. (2006). The impact of computers on the work of the principal: Changing discourses on talk, leadership and professionalism. *School Leadership & Management, 26*(1), 23-36.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223-252.

Holstead, M. S., Spradlin, T. E., Plucker, J. A., & Indiana University, Center for Evaluation and Education Policy. (2008). *Promises and pitfalls of virtual education in the United States and Indiana. education policy brief. Volume 6, Number 6, spring 2008.* Center for Evaluation and Education Policy, Indiana University.

Huett, J., Moller, L., Foshay, W. R., & Coleman, C. (2008). The evolution of distance education: Implications for instructional design on the potential of the Web. Part 3: K-12. *TechTrends: Linking Research and Practice to Improve Learning, 52*(5), 63-67.

Juang, Y., Liu, T., & Chan, T. (2008). Computer-supported teacher development of pedagogical content knowledge through developing school-based curriculum. *Educational Technology & Society, 11*(2), 149-170.

Kaestner, R. (2007). Gauging technology costs and benefits. *School Administrator, 64*(5), 28.

Kember, D. (2007). *Reconsidering open and distance learning in the developing world : Meeting students' learning needs*. London; New York: Routledge.

Klein, J. (2008). Social networking for the K-12 set. *Learning & Leading with Technology, 35*(5), 12-16.

Leonard, L. J., & Leonard, P. E. (2006). Leadership for technology integration: Computing the reality. *Alberta Journal of Educational Research, 52*(4), 212-224.

Lesisko, L. J., & Wright, R. J. (2007). *School based leadership for instructional technology*. Paper presented at the Annual Meeting of the American Educational Research Association. (Chicago: April 9-13, 2007).

McDougall, A., & Jones, A. (2006). Theory and history, questions and methodology: Current and future issues in research into ICT in education. *Technology, Pedagogy and Education, 15*(3), 353-360.

Mee, A. (2007). E-learning funding for schools: A policy paradox? *British Journal of Educational Technology, 38*(1), 63-71.

Palozzi, V. J., Spradlin, T. E., & Indiana University, Bloomington School of Education. (2006). *Educational technology in Indiana: Is it worth the investment? Education policy brief. volume 4 , number 4, spring 2006.* Center for Evaluation and Education Policy, Indiana University.

Sawtelle, S. (2008). Does this really work? The keys to implementing new technology while providing evidence that technology is successful. *Learning & Leading with Technology, 35*(8), 12-15.

Serim, F. (2007). The new gold rush: Establishing effective online learning policies. *Learning & Leading with Technology, 35*(2), 12-16.

Tompsett, C. (2007). Tipping into the abyss: With more than a virtual parachute? *ALT-J: Research in Learning Technology, 15*(2), 175-180.

Wasonga, T. A. (2007). Using technology to enhance collaborative learning. *International Journal of Educational Management, 21*(7), 585-592.

Watson, D. (2006). Understanding the relationship between ICT and education means exploring innovation and change. *Education and Information Technologies, 11*(3), 199-216.

Wishart, J. (2008). Challenges faced by modern foreign language teacher trainees in using handheld pocket PCs (personal digital assistants) to support their teaching and learning. *ReCALL, 20*(3), 348-360.

Wong, K. (2007). Implementation of ICT in primary schools in Hong Kong: Consistency and discrepancy of attitudes between school heads and teachers. *International Educational Technology (IETC) Conference*, (7th, Nicosia, Turkish Republic of Northern Cyprus, May 3-5, 2007).

Younie, S. (2006). Implementing government policy on ICT in education: Lessons learnt. *Education and Information Technologies, 11*(3), 385-400.

Zucker, A. A., Tinker, R., Staudt, C., Mansfield, A., & Metcalf, S. (2008). Learning science in grades 3-8 using probeware and computers: Findings from the TEEMSS II project. *Journal of Science Education and Technology, 17*(1), 42-48.

ICT Infrastructure, Connectivity and Accessibility

Overview

In this section, we examine issues that focus on questions of infrastructure. By "infrastructure" we mean more than computer network capacity. We present literature related to the newer tools under the contemporary discussion of ICT: mobile phones, hand-held digital assistants, ubiquitous laptop computer distribution, Web 2.0 utilities and "thin client" technologies. Of particular concern are conditions in developing countries and the connectivity implications of meeting educational needs with the ICT. Some of the topics addressed in this section overlap with discussions undertaken from different perspectives in other sections.

In a recent BBC broadcast of the program, *Digital Planet*, Gareth Mitchell (2009) discussed impending initiatives to upgrade Internet access for several African countries. These projects promise to speed-up access and lower costs of connecting to high-speed Internet backbones. For the moment such projects, such as Nigeria's MainOne Cable Company and the Eastern Africa Submarine Cable System (EASSy), will only reach selected countries and leave unsolved the challenge of last-mile links to individual homes and schools. Nevertheless, the infrastructural climate in Africa promises to change dramatically during the coming year. Educators will need to ready themselves for this shift in network infrastructure.

Challenges and constraints impacting progress

Among the steepest challenges confronting the development of access to a well-connected infrastructure appears to be a lack of effective leadership and planning, not only at the local educational level but also in the higher reaches of policy-making. Based on a study of ICT implementation in 20 European secondary schools, Mueller et al. (2007) reveal gaps in efforts to plan effectively for long-term educational transformation. They suggest that educational leadership should recognize more clearly the full range of components that support sustainable change. These include a better recognition of educational research, theory, and philosophy. Recognizing the need for change, Kozma (2008) has outlined a policy framework for social, economic and educational ICT reform in development at national levels.

Concerned about unmet ICT needs, especially in developing countries, Aczel and Hardy (2008) offer a framework for analyzing technological gaps. In addition to the obvious costs of hardware and software, they offer four categories of investment need:

- instructional design capacity,
- tutorial capacity,
- production capacity, and
- community building capacity

Rumble et al. (2007) report on the organization and structure of open schooling efforts in India and Namibia. In these, as in many countries, investments in ICT infrastructure suffer from the relatively low status accorded by government, educators and the general public to computer networked modes of teaching and learning.

Evolving approaches in the field

Much of the literature on this theme addresses the inequitable distribution of ICT resources within and across nations. This issue is commonly labeled the "digital divide." Educators sometimes think of the digital divide as a particular phenomenon of the developing world, but it also exists within the national boundaries of developed countries. In the US state of Florida, for example, Hohlfield et al. (2008) has presented a theoretical model defining "digital divide" across a variety of dimensions. Hohlfield's model reveals clear resource distinctions between high and low SES schools according to the dimensions of high-quality instruction, software access and levels of technical support for ICT implementation.

An American-based project, One Laptop per Child (OLPC), attempts to address this problem. In the Democratic Republic of Congo (DRC) Banza (2006) affirms that OLPC's $100 (US) laptop may, on the surface, seem to offer a viable resolution of the resource scarcity confronted by African schools. To citizens of affluent countries, $100 for a laptop computer may seem cheap, but in the DRC this sum represents more than one month's teacher salary. Additionally, this amount fails to account for the cost of ancillary resources such as materials, curriculum and professional development required for effective implementation. (Moreover, the $100 price tag has already escalated to more than $200.) Momanyi et al. (2006) describes the network computing lag experienced in developing countries in comparison to the developed world. As African educators increasingly declare their intention to invest in ICT, nationally-coordinated initiatives to plan, set policy and develop collective purchasing strategies are urged.

Writing respectively in global and American contexts, Ameil (2006) and Davis et al., (2007) caution against thinking about the "digital divide" in simple terms of computers and software. They have suggested that educational leaders need to consider the full scope of resources necessary for effective ICT integration. Judge et al. (2006) undertook a massive survey of more than 8000 US public schools at the early grade levels (K-3). Ironically, this research revealed that high-poverty schools tend to possess better computer-to-student ratios than low-poverty schools. These data, however, simply count computers; they say little or nothing about the condition of those computers or the uses to which they are put. However, children in relatively affluent schools have superior access to technology in their homes. (An interesting subtext of this study suggests that early-grade reading achievement is negatively associated with frequent use of reading software.)

Various strategies have been employed in different countries as incentives for schools to become well-connected to data networks. Although the Internet is acknowledged as an important source of learning, Ryle et al. (2008) report from Indonesia that cultural values and existing infrastructural constraints can inhibit the implementation of Internet connectivity. Young Indonesians are slow to abandon cultural norms in order to embrace digital tools for networked learning. According to Park et al. (2007), the US federal government has instituted a nationwide program of telecommunications discounts called the "e-rate." Although this program has improved network access across public schools, it has been criticized for its inflexibility and for its failure to account for the myriad ICT costs beyond network access. The e-rate initiative should be better synchronized with other funding sources.

In Latin America, where illiteracy continues to plague indigent, primarily indigenous populations, m-learning is under examination as an important strategy to improve literacy (Kim et al., 2008). Kim perceives literacy as the foundation for long-term personal prosperity, health, safety, career success and continuing education. In the United States, efforts have also been made to improve network access and ubiquitous laptop computing to populations living in very remote Alaskan regions (McHale, 2007; Subramony, 2007). Some children reside so far from population centers that they cannot physically attend school. Thus, they depend crucially on resources that can be made available in their homes and communities. Based on an ethnographic study, Subramony concluded that the success of such investments depends as much on successful pedagogical integration as it does on the distribution of educational resources via computer networks.

Several strategies reveal themselves in the literature to improve access to the learning benefits of ICT: one-to-one ubiquitous laptop computing initiatives, a migration from fixed computers to mobile devices, increased reliance on digital resources accessible "in the cloud" (Web 2.0), and a re-dedication to traditional technologies such as broadcast radio. Let us examine these strategies case by case.

A qualitative study of three demographically diverse elementary school systems in California examined the outcomes of a one-on-one laptop initiative (Grimes and Warschauer 2008). The results were mixed. The strongest student achievement gains appeared to be in writing, but in the initial stages of the project there appeared to be performance losses in mathematics and English. Livingston (2007) has outlined a variety of creative strategies for financing the substantial costs of a one-to-one laptop program.

Hoffman (2007) and McHale (2006) describe the establishment of two American school district-wide wireless network projects that support multiple laptops, one in Ohio and the other in Maryland. Notwithstanding increased security concerns, wirelessly-connected laptops substantially elevated access to networked ICT resources. The wireless network in Maryland provides service to portable laptop carts that are provided on-demand to classrooms. This approach comes close to offering the advantage of a one-to-one laptop ratio without requiring the purchase of a unique computer for each student. Looking ahead, an evolution of wireless networking capacity toward service of mobile devices, in addition to computers, is anticipated. In an effort to control spiraling ICT costs, one urban New England school district has migrated from the conventional distribution of computer access to a "terminal server - thin client" approach, according to St. Jean (2008). It is too early to determine the efficacy of this new strategy.

Ubiquitous laptop initiatives have been attempted in broader jurisdictions than local school districts. As previously described, the OLPC project attempts to infuse laptop computers across entire countries in the developing world. In Canada, the Eastern Townships regional school board of Québec has recently scaffolded its ubiquitous one-laptop-per-child project, originally launched in 2003, into a formal trans-national cooperative agreement with Uruguayan schools (Canuel, 2009).

The work of Grimes and Warschauer has already been mentioned. Warschauer (2006) additionally reports on statewide initiatives undertaken in California and Maine. He has cautioned that ubiquitous laptop computer investments do not, and should not be expected to, achieve such objectives as improved test scores, reformed schools or equitable achievement among student populations. However, these programs have been shown to advance engaged learning, to promote acquisition of 21st Century skills, and to broaden access to educational resources. Planning for ubiquitous laptop infusion needs to work from a baseline of educational goals and to be clear about how success will be measured. Additional narrative on the implications of one-to-one laptop computer initiatives appears in the section of this report entitled "Integration of ICTs into Teaching and Learning."

Several observers have suggested that resource-poor regions of the world should retain their commitments to analog technologies such as radio and broadcast television (Kinuthia, 2008). Infrastructure and know-how already exists for these technologies, and they can be augmented by other strategies to promote engaged learning and student interaction. Kinuthia (2008) regards the digital divide as a "knowledge divide" which traditional technologies are well-positioned to address. Calandra et al. (2008) advocates investment in low-bandwidth digital audio technology where high-speed Internet access is unavailable. Berman (2008) recommends similar strategies for South Asia. James (2008) believes that ICT resource and investment models appropriate for the developed world do not apply in developing countries because these models have not been designed with equitable distribution in mind.

Researchers might legitimately ask if ubiquitous laptop computing any longer represents a viable future for ICT investment. With the burgeoning distribution of mobile devices connected to cellular telephone networks, laptops may represent a disappearing phenomenon. Swan (2007) has outlined the unique affordances of mobile devices, especially resulting from the fact that they are carried by virtually all young people, anywhere, and at any time around-the-clock. The failure of educators to acknowledge this reality will exacerbate the growing "disconnect" between schools and their constituencies. Recognizing the display limitations of mobile devices, Huang et al. (2008) describe innovative models to support synchronous learner access to educational content using these tools.

Motlik and Scott (2008) suggest that future African and Asian ICT development should concentrate resource development on mobile technologies rather than Web-based strategies. The wireless infrastructure for mobile telecommunication is already in place or under development. Compared to Internet-connected computers, the popular distribution of mobile devices is relatively familiar, easy-to-use and widespread in developing regions. These attributes are deemed important for adoption in any culture (Norris, 2007). Norris et al. (2008) advance the further case that schools and teachers need to adopt mobile 21st-century tools for 21st-century learners. As matters now stand, schools are not exposing students to these tools, thus widening the technology gap between home and school.

Ramaswami (2008) reports success from North Carolina where state-level leadership is supporting its public schools with resources and strategies to teach mathematics and science with mobile phones and other handheld devices. Patten et al. (2006) have analyzed the pedagogical underpinnings -- real and theorized -- for hand-held ICT tools. They argue that the unique

affordances of hand-held devices should not simply be applied to replicating more efficiently the practices of earlier technologies. Rather, they advocate the creation of innovative scenarios peculiar to the capacities of these newer tools.

Soule (2008) makes a similar case for Web 2.0 teaching and learning innovations. Although young people (the so-called millennial generation) are regular, facile users of wireless mobile technologies, they have not abandoned the use of networked computers. Social networking (e.g. Facebook, MySpace) blends in with mobile text messaging and file-sharing to provide a complete picture of useful network application. Building on the research of Albert Bandura, Girasoli and Hannafin (2007) urge the use of asynchronous CMC tools to promote student self-efficacy and hence academic performance.

What do students think of m-learning? Corvus et al. (2008) note the advancing incursion of mobile phone technology across the various learner educational levels, especially at universities and colleges. More than 300 students from the Near East University in Turkey were surveyed for their perspectives. Student opinion tended to be positive, partly because mobile technologies are already embedded in their day-to-day lives. Neither gender nor national origin was related to the opinions expressed.

Whether or not investments in infrastructure and access actually produce beneficial results remains open to debate. Mouza (2008) presents results from a mixed-mode study examining outcomes of a laptop-intensive investment in poor, urban American schools. Mouza claims that children in the experimental classrooms demonstrated improved engagement and motivation compared with their control group counterparts.

In Chile, however, a summative account of the nationwide ICT infrastructure initiative, labeled "Enlaces," offered mixed results. Despite acknowledged gains in information access and distribution of resources, there is no hard evidence of improved student learning. According to Shen et al. (2008) potential benefits from infrastructure investments in Chinese schools have been curtailed because of a national tendency to discourage active student engagement in favor direct instruction techniques. In this case, teaching style appears to matter more than the ICT tools used to implement it.

<u>"Hot" topics in this field</u>

The literature emerging from this search pinpoints a variety of pressing contemporary issues related to the themes of connectivity and accessibility. Among the most prominent issues are:

1. Addressing the digital divide, domestically and globally,
2. Assessing one-to-one computer distribution, in and outside the developed world,
3. Assessing the potential of m-learning devices for teaching and learning,
4. Assessing the potential of Web 2.0 tools to promote cost-effective teaching and learning,
5. Creating analytical models to assess the benefits of costs invested:
    a. efficacy of ubiquitous laptop investment in the light of emerging 3G mobile devices,
    b. total cost of program development,
    c. justifying ITC investment for building infrastructure and assuring access,

6. Assessing the balance between wired and wireless network development,
7. Addressing questions of effective leadership in assuring access to ICT resources.

Research gaps suggesting further investigation

The literature reported above seems to indicate the need for continuing attention on questions of ICT policy and educational leadership, providing clearer models to link known principles of effective leadership to the particular needs of connectivity and access. Strategies are needed that will enable educators to respond nimbly to technological changes in the larger world. Educators tend to become trapped in the technologies with which they have become familiar. Oftentimes, by the time they become familiar with new developments, events in the broader world have passed them by. This phenomenon occurs at an increasingly rapid pace. If educators continue to make 20th-century decisions in a 21st-century setting, scarce resources will be wasted and educational opportunities lost.

Paralleling these issues is a need to create stable models for evaluating the scholarly outcomes of expenditures made, for linking new investments to the realities of existing culture and infrastructure, and for assessing the benefits of these investments. Through its aim of distributing low-cost laptop computers to schools in developing countries the OLPC project, for example, appears to address a pressing need. However, important ancillary questions about this project need closer scrutiny. What curriculum supports a classroom infusion of computers? How are teachers equipped with the pedagogical skills to capitalize on the sudden availability of laptops? Where is the infrastructure to support the networking of these computers? How is the infusion of laptops maintained and sustained over time? How should implementing teachers be trained and who should do the training? With the advent of 3G mobile technologies, should developing countries be concentrating their investments in laptop computing in the first place?

References

Aczel, J. C., Peake, S. R., & Hardy, P. (2008). Designing capacity-building in E-learning expertise: Challenges and strategies. *Computers & Education, 50*(2), 499-510.

Amiel, T. (2006). Mistaking computers for technology: Technology literacy and the digital divide. *AACE Journal, 14*(3), 235-256.

Banza, N. N. (2006). Are the rural schools of the Democratic Republic of Congo ready for the $100 laptop? *Turkish Online Journal of Educational Technology, 5*(4).

Barbour, M. K. (2007). Portrait of rural virtual schooling. *Canadian Journal of Educational Administration and Policy,* (59), 1-21.

Berman, S. D. (2008). 65. ICT-based distance education in South Asia. *International Review of Research in Open and Distance Learning, 9*(3), 1-6.

Calandra, B., Barron, A. E., & Thompson-Sellers, I. (2008). Audio use in E-learning: What, why, when, and how? *International Journal on E-Learning, 7*(4), 589-601.

Canuel, R. (2009, January 12). Designing the future of children around the world. *Anytime Anywhere Learning Foundation Newsletter*. Retrieved from: http://www.aalf.org/Issues/view.aspx?id=20

Cavus, N., Bicen, H., & Akcil, U. (2008). The opinions of information technology students on using mobile learning. *Paper Presented at the International Conference on Educational Sciences (ICES),* Famagusta, Cyprus.

Davis, T., Fuller, M., Jackson, S., Pittman, J., & & Sweet, J. (2007). *A national consideration of digital equity.* International Society for Technology in Education (ISTE).

Girasoli, A. J., & Hannafin, R. D. (2008). Using asynchronous AV communication tools to increase academic self-efficacy. *Computers & Education, 51*(4), 1676-1682.

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

Hoffman, R. (2007). A wireless world: Charles County public schools makes wireless universal. *Technology & Learning, 27*(8), 27-29.

Hohlfeld, T. N., Ritzhaupt, A. D., Barron, A. E., & Kemker, K. (2008). Examining the digital divide in K-12 public schools: Four-year trends for supporting ICT literacy in Florida. *Computers & Education, 51*(4), 1648-1663.

Huang, Y., Kuo, Y., Lin, Y., & Cheng, S. (2008). Toward interactive mobile synchronous learning environment with context-awareness service. *Computers & Education, 51*(3), 1205-1226.

James, J. (2008). The digital divide across all citizens of the world: A new concept. *Social Indicators Research, 89*(2), 275-282.

Judge, S., Puckett, K., & Bell, S. M. (2006). Closing the digital divide: Update from the early childhood longitudinal study. *Journal of Educational Research, 100*(1), 52-60.

Kabonoki, S. K. (2008). Access to technology and readiness to use it in learning. *Open Learning, 23*(2), 113-121.

Kim, P., Miranda, T., & Olaciregui, C. (2008). Pocket school: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America. *International Journal of Educational Development, 28*(4), 435-445.

Kinuthia, W. (2008). Another spotlight on the continent: "TechTrends" in Africa. *TechTrends: Linking Research and Practice to Improve Learning, 52*(4), 21-23.

Kozma, R. B. (2008). Comparative analysis of policies for ICT in education. *International handbook of information technology in primary and secondary education*. New York: Springer.

Livingston, P. (2007). Affording 1:1-- Knowing your district's technology needs and creating workable solutions are key to a successful 1:1 plan. *Technology & Learning, 27*(12), 8.

McHale, T. (2006). One-to-one in Ohio: Part Two in our series on one-to-one programs. *Technology & Learning, 27*(4), 30.

McHale, T. (2007). One-to-one in Alaska: In the remote Alaskan interior, students are reaping the benefits of laptop computing. *Technology & Learning, 27*(8), 24-26.

Mitchell, G. (2009, March 31). Digital Planet: Africa broadband, Tim Berners-Lee, great firewall of China and galaxy zoo. *BBC World Service*. Retrieved from: http://www.bbc.co.uk/iplayer/console/p002mbt8

Momanyi, L., Norby, R., & Strand, S. (2006). The need for integration of technology in K-12 school settings in Kenya, Africa. *AACE Journal, 14*(2), 154-177.

Motlik, S. (2008). Mobile learning in developing nations. *International Review of Research in Open and Distance Learning, 9*(2), 1-7.

Mouza, C. (2008). Learning with laptops: Implementation and outcomes in an urban, under-privileged school. *Journal of Research on Technology in Education, 40*(4), 447-472.

Muller, J., Sancho Gil, J. M., Hernandez, F., Giro, X., & Bosco, A. (2007). The socio-economic dimensions of ICT-driven educational change. *Computers & Education, 49*(4), 1175-1188.

Norris, C., Shin, N., & Soloway, E. (2007). Educational technology for the mainstream: A call for designing for simplicity and reliability. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 6-9.

Norris, C., & Soloway, E. (2008). Handhelds: Getting mobile. *District Administration, 44*(8), 20-24.

Park, E., Sinha, H., & Chong, J. (2007). Beyond access: An analysis of the influence of the E-rate program in bridging the digital divide in American schools. *Journal of Information Technology Education, 6*, 387-406.

Patten, B., Sanchez, I. A., & Tangney, B. (2006). Designing collaborative, constructionist and contextual applications for handheld devices. *Computers and Education, 46*(3), 294-308.

Ramaswami, R. (2008). Fill 'er up. *T.H.E. Journal, 35*(5), 32-38.

Rumble, G., Koul, B. N., & Commonwealth, O. L. (2007). *Open schooling for secondary & higher secondary education. Costs and effectiveness in India and Namibia.* Commonwealth of Learning.

Rye, S. A., & Zubaidah, I. (2008). Distance education and the complexity of accessing the Internet. *Open Learning, 23*(2), 95-102.

Sanchez, J., & Salinas, A. (2008). ICT & learning in Chilean schools: Lessons learned. *Computer Education, 51*(4), 1621-1633.

Shen, R., Wang, M., & Pan, X. (2008). Increasing interactivity in blended classrooms through a cutting-edge mobile learning system. *British Journal of Educational Technology, 39*(6), 1073-1086.

Soule, H. (2008). Transforming school communities: Creating dialogue using Web 2.0 tools. *Learning & Leading with Technology, 36*(1), 12-15.

St. Jean, M. (2008). Going on a desktop diet. *Learning & Leading with Technology, 36*(1), 22-27.

Subramony, D. P. (2007). Understanding the complex dimensions of the digital divide: Lessons learned in the Alaskan arctic. *Journal of Negro Education, 76*(1), 57.

Swan, K., Kratcoski, A., & van't Hooft, M. (2007). Highly mobile devices, pedagogical possibilities, and how teaching needs to be reconceptualized to realize them. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 10-12.

Warschauer, M. (2006). Going one-to-one. *Educational Leadership, 63*(4), 34-38.

Integration of ICTs into Teaching and Learning

Overview

In this section of our narrative, we address various factors related to the successful integration of ICT into the curriculum. Literature citations address the question of what contributes to effective implementation. For example, it is suggested that the affordances offered by newer technologies should prompt a fundamental rethinking of educational purpose and practice. This suggestion carries implications for educational leadership and policy. Several researchers cite the importance of teacher education, professional development and support to reflect fundamental reorientation of educational vision so that practitioners can move forward boldly to seize opportunities that were unimaginable only recently.

Challenges and constraints impacting progress

Perhaps the greatest challenges of ICT integration relate to vision, policy and leadership. ICT is changing faster than educators have shown themselves able to track. In order for eac sector to capitalize on the knowledge of other sectors, this suggests a need for closer cooperation among educators, university researchers, teacher preparation personnel, government policy makers, non-government organizations (NGOs), and the private sector. To put it charitably, the prior track record for such collaboration is modest. Better strategies are needed to evaluate the impact of efforts to integrate ICTs, especially so that competing practices can be compared for future selection.

These challenges appear to exist equally in the developed and the developing world. In Turkey, for example, survey research by Gulbahar (2008) on the integration of ICT for 4th and 5th grade social studies reveals that a general willingness of teachers to innovate is not matched by sufficient ICT resources in the classroom or by the in-service professional development that sustained innovation would require.

Evolving approaches in the field

Literature emerging between 2006 and 2008 on the integration of ICT into teaching and learning is robust, building upon an even more extensive literature base preceding it.

Let us begin considering the relationship between transformative ICT integration and school structure. Drenoyianni (2006) provides a philosophical discussion on the contemporary condition of ICT for schooling. According to her, current school practice tends to reinforce existing educational values and structures reinforcing the positive and negative aspects. For ICTs to be used to transformationally, educational leadership must reevaluate the fundamental meaning of schooling and what this implies for institutional structure. Technology cannot lead school reconceptualization; technology must reflect it. Similarly, reporting from Norway, Krumsvik (2008) urges a strengthening of the theoretical foundation for ICT integration, especially among classroom teachers expected to undertake it.

As teachers become more secure with underlying research, school policy should also be well anchored in theory. Emily Wong (2008) offers a qualitative case study of eight schools in Hong Kong and Singapore where factors associated with transformational ICT integration were analyzed. Factors related to effective transformation include: leadership promoting future collaboration and experimentation, and teacher commitment to learner-centered pedagogy. Tondeur et al. (2008) report from Belgium that the efficacy of ICT integration can be predicted by the characteristics of school leadership. Schools characterized by participatory management and decision-making, supported by effective ICT policy, typically implement a relatively efficacious integration of technology into the curriculum.

Discussion about school structure leads to consideration of teacher characteristics related to ICT integration. Drent and Meelissen (2008) attribute innovative ICT integration in the Netherlands primarily to the entrepreneurial spirit possessed by teachers. Not surprisingly, risk takers seem to be more transformational than the risk-averse. Several studies present a dismal picture of actual practice. For example, a mixed-method case analysis of Cypriot elementary classrooms found sporadic and superficial use of ICTs, tending more toward reinforcement of traditional practice than enablement of curricular transformation (Eteokleous, 2008). This sense is reinforced by a study of technology use in New Zealand secondary schools by Lai and Pratt (2008).

Gorder (2008) suggests that teacher experience is strongly related to actual ICT practice. Her study found that effective use of technology was related to technological comfort levels and the liberty to shape instruction to teacher-perceived student needs. VanFossen and Waterson (2008) conducted survey research among high school social studies classes in the US state of Indiana. Results showed a wide disparity between higher-order and lower-order Internet use to support social studies teaching. The single most significant predictor of the "order level" of classroom Internet use centered upon core teacher pedagogical belief.

Survey research conducted in nearly 800 Québec elementary and secondary schools examine the link between professional values and kinds of technology use. Important values determining the quality of ICT use are: teacher expectations of success; perceived value of the tools implemented, and personal teacher use outside the school. ICT is predominantly used for "information seeking" purposes rather than for student creation, collaboration or the original production of knowledge. According to Yuen and Ma (2008) the nature of ICT implementation among Hong Kong teachers-in-training seems related to ease of tool use and perceived teacher self-efficacy.

What promotes the perception of self-efficacy among teachers? Several observers point to the importance of professional development and ongoing support. Some of these issues have been discussed in this document's thematic section on teacher education, but the literature cited in this section explicitly connects professional development to classroom integration. Gulbahar (2008) views the lack of professional development as a major barrier to ICT integration. Mueller et al. (2008) connect professional development with effective technology integration. Based on a randomized survey of nearly 400 elementary and secondary teachers, professional development and the ongoing reinforcement of good practice are among the strongest predictors of integrative success.

Two studies explicitly correlate ICT professional development programs to improved classroom integration. Overbaugh and Lu (2008) surveyed hundreds of K-12 participants in a US federally-funded professional development program. Results indicated a positive relationship between program completion and teacher perceptions of ICT self-efficacy. Through qualitative document analysis, Schibeci et al. (2008) affirm that a funded ICT professional development project promoted growing technology sophistication and confidence among Australian primary school teachers. Over time, this growing competence progressed toward genuinely transformed practice. These relationships seem also to pertain in the developing world. Mixed-mode research on novice Rwandan teachers indicates high motivation levels to innovate with ICT. Based on this motivation, successful integration is better secured by ongoing professional development, availability of resources, and teacher autonomy of professional judgment.

Ongoing professional support for ICT integration is effectively promoted by electronically mediated communities-of-practice (eCOPs). According to Parr and Ward (2006), eCOPs help to reduce professional isolation, especially for teachers practicing in remote geographical areas. Success with this technique is better assured in situations where commonly-held professional needs are clearly articulated and served, and where access to online community tools is simple and transparent. Among secondary-level history and science teachers, Haydn and Barton (2008) discovered a positive correlation between teacher self-image and satisfaction with the ICT curriculum resulting from professional time regularly made available for collaboration and communication about ICT practice. Newer Web 2.0 technologies (e.g. social networks, Wikis, asynchronous chatting) can support new directions in teacher communication for their own professional development, according to Sawchuck (2008).

From a Norwegian case study, Elstad (2006) affirms that the dynamics of the technology-infused classroom reduces teacher control thereby creating a threat that students will carry out non-educational activity with the technology devices made available to them. (Teacher control, however, may not be the point of ICT transformation in the curriculum.) Groff and Haass (2008) offer innovative ideas about how computer-based games, simulations, and social networking can be put to constructive educational use in a well-managed school setting. These authors acknowledge the potential disruption of newer technologies to traditional educational practice, but suggest that educational leaders might beneficially assume responsibility for devising creative ways to transform disruptive student behavior into constructive learning activity.

Several studies address the challenges that the acceleration of technological innovation pose for ICT integration. Several "ubiquitous computing" projects are described. Burns and Polman (2006) assessed the middle school infusion of one-to-one wireless laptops throughout the curriculum. Project evaluation points to performance improvement in the following areas: teaching skills, professional communication, learner knowledge acquisition, and quality of student-teacher dialogue. Based on a mixed-mode case study, Dunleavy et al. (2007) posit that massive computer infusion among students can elevate ordinary curricular ICT applications into transformational practice in American middle schools. To justify the high cost of such initiatives, high-quality professional development must accompany the computer investments. Kay (2006) examined the relationship between ubiquitous one-to-one computer distribution and gender differences between pre-service teacher groups. Using pre-and post-program

observational analysis, gender differences noted before program launch appeared to equalize by the time that the program had ended.

Ubiquitous one-to-one computer infusion, however, has generated criticism. Clausen et al. (2008) report on a survey of 74 school administrators from the state of Indiana in the USA. This report challenges some of the more positive assumptions about the one-to-one laptop initiative, concluding that massive hardware distribution efforts of this nature often fail to meet expectations of instructional change and student learning outcomes. Such major funding investments must be supported by clear articulations of vision, according to Clausen, and by teacher/administration commitment to effective curricular integration. Failing this, investment goals may not be achieved. (Further discussion on the implications of one-to-one laptop computer initiatives appears in the section of this report entitled "Infrastructure, Connectivity and Accessibility.")

Evidence exists that laptop use in an urban elementary school has promoted the acquisition of higher-order thinking skills among students (Barron and Harmes, 2006). Banyard et al. (2006) performed case studies at 37 primary and secondary schools on students' self-regulation of learning and higher-order thinking where the large-scale infusion of ICT made a distinct contribution. Positive outcomes of a primary school curriculum that integrates gaming technology to foster higher-order reasoning ability are reported by Bottino et al. (2006, 2007). Blaisdell (2006) describes the potential of collaborative computer-based virtual environments (e.g. "Second Life") to engage children in learning activities that they might otherwise eschew. Blaisdell suggests that this kind of integration capitalizes on gaming behaviors already familiar to young learners. However, Song (2007) suggests that the predicted educational revolution prompted by the infusion of handheld devices has not yet occurred in any sustainable manner. She bases this perception on a meta-analysis of other research.

In addition to the relatively concrete issues related to ITC integration, various human factors also bear discussion. Beisser (2006) describes a project through which Lego-Logo applications were implemented in US midwestern elementary schools. Mixed-mode research findings suggest that, as a result of their exposure to this project, girls' gender self-perceptions about technology competence improved. Boys' self-image of their technological gender superiority did not change. In Greece, Vekiri and Chronaki (2008) surveyed more than 300 elementary school boys and girls, revealing that technological conditions in their homes influence their attitudes about ICT in school. They found is that Greek boys use computers more frequently and with greater parental support than do girls, and that such support is related differentially to their respective perceptions of self-efficacy.

Qualitative research on 15 to 25 midwestern American teachers on ICT decision-making prompted Oncu at al. (2008) to report that teacher decisions were related primarily to the following perceptions: resource availability, tool applicability, collegial influence, self-assessment of technological competence, and prior student knowledge. Thus, ICT decision-making may stem from factors similar to other kinds of curricular decision-making.. Russell et al. (2007) surveyed nearly 3000 teachers and determined that the quality of ICT integration is related to length of teacher service.

Wijekumar et al. (2006) warns that educational decision-makers have failed to heed the effect of ICT affordances on curricular integration. Affordances are defined as "the interaction supported by [tools] for each individual … affected by their prior experience." The prior experience of many young people is to use technology for gaming and entertainment. Thus, they tend not to be prepared for "learning" affordances. The success of ICT integration will continue to be limited until such affordances are fully taken into account. Does this failure create implacable digital miscommunication between generations? Probably not, according to Selwyn (2006) who believes that conventional wisdom about a generational divide is overblown. His research failed to reveal a technology-driven communications barrier between the younger people and their teachers. But there is a different communications gap according to Tondeur et al. (2007). He suggests that the technical focus placed by teachers on ITC use aligns poorly with the more educationally integrative focus of school curriculum. Policy and practice needs to remedy this gap so that teachers think of ITC as a means for teaching and learning more than as a technological toolbox.

"Hot" topics in this field

In this section of the literature review, the following questions present themselves as high priorities:

1. In what way should education be re-visualized to optimize the impact of emerging ICT technologies?
2. What resources are needed to create and sustain successful classroom integration?
    a. network access/infrastructure
    b. software
    c. training and professional development
    d. planning time
3. How do we evaluate the success of integration efforts?
4. In what way can successful practices be disseminated across wider school populations?
5. How can technology be used to support ICT development by teachers writing curriculum and designing lesson plans?
6. How can we define effective leadership for ICT integration and assure that it is applied where needed?

Research gaps suggesting further investigation

The link between educational practice, particularly for ICT integration, and background theory is weak. More attention is warranted to reduce this gap. From this literature review, it appears that better research strategies are needed to support educational leaders and classroom personnel to make the best use of the resources that are emerging at an increasingly rapid pace. Outcome evaluations of pedagogical practice need to continue as technologies become more fully secured in schools. Commonly-applicable research templates would help teachers compare practices against one another, the better to inform their own curricular choices. By the same token, improved evaluation protocols are needed for the learning benefits of ICT costs incurred. Although the current literature reveals vignettes of teacher and student attitudes about the technologies they are being asked to adopt, a more comprehensive perspective about these perceptions would help inform decision-making.

References

Banyard, P., Underwood, J., & Twiner, A. (2006). Do enhanced communication technologies inhibit or facilitate self-regulated learning? *European Journal of Education, 41*, 473-489.

Barron, A. E., & Harmes, J. C. (2006). Authentic instruction in laptop classrooms: Sample lessons that integrate Type II applications. *Computers in the Schools, 22*, 119-130.

Beisser, S. R. (2006). An examination of gender differences in elementary constructionist classrooms using Lego/Logo instruction. *Computers in the Schools, 22,* 7-19.

Blaisdell, M. (2006). Educational gaming: All the right MUVEs. *T.H.E.Journal, 33*(14), 28-38.

Bottino, R. M., Ferlino, L., Ott, M., & Tavella, M. (2007). Developing strategic and reasoning abilities with computer games at primary school level. *Computers & Education, 49*(4), 1272-1286.

Bottino, R. M., & Ott, M. (2006). Mind games, reasoning skills, and the primary school curriculum. *Learning, Media & Technology, 31*(4), 359-375.

Burns, K., & Polman, J. (2006). The impact of ubiquitous computing in the internet age: How middle school teachers integrated wireless laptops in the initial stages of implementation. *Journal of Technology and Teacher Education, 14*(2), 363-385.

Charalambous, K., & Ioannou, I. (2008). The attitudes and opinions of Cypriot primary teachers about the use of the Internet for their professional development and as an educational tool. *Learning, Media and Technology, 33*(1), 45-57.

Clausen,J. M., Britten, J., & Ring, G. (2008). Envisioning effective laptop initiatives. *Learning & Leading with Technology 36*(1), 18-22.

Dalgarno, N., & Colgan, L. (2007). Supporting novice elementary mathematics teachers' induction in professional communities and providing innovative forms of pedagogical content knowledge development through information and communication technology. *Teaching and Teacher Education: An International Journal of Research and Studies, 23*(7), 1051-1065.

Daly, T. (2008). School culture and values-related change: Towards a critically pragmatic conceptualisation. *Irish Educational Studies, 27*(1), 5-27.

Drenoyianni, H. (2006). Reconsidering change and ICT: Perspectives of a human and democratic education. *Education and Information Technologies, 11*(3), 401-413.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187-199.

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.

Elstad, E. (2006). Understanding the nature of accountability failure in a technology-filled, laissez-faire classroom: Disaffected students and teachers who give in. *Journal of Curriculum Studies, 38*(4), 459-481.

Eteokleous, N. (2008). Evaluating computer technology integration in a centralized school system. *Computers & Education, 51*(2), 669-686.

Gorder, L. M. (2008). A study of teacher perceptions of instructional technology integration in the classroom. *Delta Pi Epsilon Journal, 50*(2), 63-76.

Groff, J., & Haas, J. (2008). Web 2.0: Today's technology, tomorrow's learning. *Learning & Leading with Technology, 36*(1), 12-15.

Gulbahar, Y., & Guven, I. (2008). A survey on ICT usage and the perceptions of social studies teachers in Turkey. *Educational Technology & Society, 11*(3), 37-51.

Hartley, J. (2007). Teaching, learning and new technology: A review for teachers. *British Journal of Educational Technology, 38*(1), 42-62.

Hartnell-Young, E., & Vetere, F. (2008). A means of personalising learning: Incorporating old and new literacies in the curriculum with mobile phones. *Curriculum Journal, 19*(4), 283-292.

Haughey, M. (2006). The impact of computers on the work of the principal: Changing discourses on talk, leadership and professionalism. *School Leadership & Management, 26*(1), 23-36.

Haydn, T., & Barton, R. (2008). "First do no harm": Factors influencing teachers' ability and willingness to use ICT in their subject teaching. *Computers & Education, 51*(1), 439-447.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223-252.

Kay, R. (2006). Addressing gender differences in computer ability, attitudes and use: The laptop effect. *Journal of Educational Computing Research, 34*(2), 187-211.

Krumsvik, R. (2008). The view of knowledge and the new national curriculum in Norway. *US-China Education Review, 5*(7), 13-28. Retrieved from: http://www.teacher.org.cn/doc/ucedu200807/ucedu20080702.pdf

Lai, K., & Pratt, K. (2008). Positive to a degree: The effects of ICT use in New Zealand secondary schools. *Computers in the Schools, 24*, 95-109.

Li, X., Atkins, M. S., & Stanton, B. (2006). Effects of home and school computer use on school readiness and cognitive development among Head Start children: A randomized controlled pilot trial. *Merrill-Palmer Quarterly: Journal of Developmental Psychology, 52*(2), 239-263.

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons. *British Journal of Educational Technology, 39*(5), 807-828.

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

McDougall, A., & Jones, A. (2006). Theory and history, questions and methodology: Current and future issues in research into ICT in education. *Technology, Pedagogy and Education, 15*(3), 353-360.

McKenney, S. (2008). Shaping computer-based support for curriculum developers. *Computer Education, 50*(1), 248-261.

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers & Education, 51*(4), 1523-1537.

Mukama, E., & Andersson, S. B. (2008). Coping with change in ICT-based learning environments: Newly qualified Rwandan teachers' reflections. *Journal of Computer Assisted Learning, 24*(2), 156-166.

Oncu, S., Delialioglu, O., & Brown, C. A. (2008). Critical components for technology integration: How do instructors make decisions? *Journal of Computers in Mathematics and Science Teaching, 27*(1), 19-46.

Overbaugh, R., & Lu, R. (2008). The impact of a NCLB-EETT funded professional development program on teacher self-efficacy and resultant implementation. *Journal of Research on Technology in Education, 41*(1), 43-61.

Parr, J., & Ward, L. (2006). Building on foundations: Creating an online community. *Journal of Technology and Teacher Education, 14*(4), 775-793.

Pierce, R., & Stacey, K. (2008). Using pedagogical maps to show the opportunities afforded by CAS for improving the teaching of mathematics. *Australian Senior Mathematics Journal, 22*(1), 6-12.

Russell, M., O'Dwyer, L. M., Bebell, D., & Tao, W. (2007). How teachers' uses of technology vary by tenure and longevity. *Journal of Educational Computing Research, 37*(4), 393-417.

Sawchuk, S. (2008). Sites mimicking social networks set up for staff development. *Education Week, 28*(1), 1.

Schibeci, R., MacCallum, J., Cumming-Potvin, W., Durrant, C., Kissane, B., & Miller, E. (2008). Teachers' journeys towards critical use of ICT. *Learning, Media and Technology, 33*(4), 313-327.

Selwyn, N. (2006). Exploring the "digital disconnect" between net-savvy students and their schools. *Learning, Media & Technology, 31*(1), 5-17.

Song, Y. (2007). Educational uses of handheld devices: What are the consequences? *TechTrends: Linking Research and Practice to Improve Learning, 51*(5), 38-45.

Tondeur, J., Valcke, M., & van Braak, J. (2008). A multidimensional approach to determinants of computer use in primary education: Teacher and school characteristics. *Journal of Computer Assisted Learning, 24*(6), 494-506.

Tondeur, J., van Braak, J., & Valcke, M. (2007). Towards a typology of computer use in primary education. *Journal of Computer Assisted Learning, 23*(3), 197-206.

Tondeur, J., van Braak, J., & Valcke, M. (2007). Curricula and the use of ICT in education: Two worlds apart? *British Journal of Educational Technology, 38*(6), 962-976.

Valadez, J. R., & Duran, R. (2007). Redefining the digital divide: Beyond access to computers and the Internet. *High School Journal, 90*(3), 31-44.

VanFossen, P. J., & Waterson, R. A. (2008). "It is just easier to do what you did before...": An update on internet use in secondary social studies classrooms in Indiana. *Theory and Research in Social Education, 36*(2), 124-152.

Varma, K., Husic, F., & Linn, M. C. (2008). Targeted support for using technology-enhanced science inquiry modules. *Journal of Science Education and Technology, 17*(4), 341-356.

Vekiri, I., & Chronaki, A. (2008). Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school. *Computers & Education, 51*(3), 1392-1404.

Wijekumar, K. J., Meyer, B. J. F., Wagoner, D., & Ferguson, L. (2006). Technology affordances: The "real story" in research with K-12 and undergraduate learners. *British Journal of Educational Technology, 37*(2), 191-209.

Wong, E. M. L., Li, S. S. C., Choi, T., & Lee, T. (2008). Insights into innovative classroom practices with ICT: Identifying the impetus for change. *Educational Technology & Society, 11*(1), 248-265.

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and Teacher Education, 14*(1), 173-207.

Yuen, A. H. K., & Ma, W. W. K. (2008). Exploring teacher acceptance of E-learning technology. *Asia-Pacific Journal of Teacher Education, 36*(3), 229-243.

Teacher Education and ICTs

Overview

Existing literature on the relationship between teacher preparation (pre-service, in-service) and the application of ICT in school classrooms is substantial. Prior to 2006, several studies suggested inadequate, insufficient or unsatisfactory teacher education for ICTs. Several of these earlier studies base their conclusions on surveys of teacher and/or student perception. Other research (Topp, 1996; Strudler, McKinney, Jones and Quinn, 1999) points to the importance of embedding ICTs throughout teacher education curriculum in a manner that reflects "technology-across-the-curriculum" strategies recommended for effective schooling. Prior research has suggested that the extensive and persistent use of such constructivist techniques as electronic portfolios, shared workspace, project-based research in teacher education point to more positive attitudes and more effective subsequent use of ICT in schools (McKinney, 1998; Kim, Sharp and Thompson, 1998).

Challenges and constraints impacting progress

From the narrative emerging in more recent research, Barak (2006) joins several other researchers (Buettner, 2006; Ottevanger et al. 2007), in questioning the efficacy of teacher preparation for the successful application of ICTs in school classrooms. If the quality of teaching depends, in some significant measure, on the way teachers were taught, it may reasonably be argued that teacher education programs treating ICT as a separate phenomenon of study will probably result in the unimaginative subsequent integration of technology into the school curriculum.

Several studies address the question of school conditions that greet emerging teachers as they transition from their programs of professional preparation to actual classroom teaching practice. Reporting from Australia on the disconnection between the ideals of teacher preparation and the realities of schooling, Carr and Chambers (2006) address the tendency of schools to discourage shared professional reflection among teachers. In a Norwegian context, Krumsvik (2006) concludes that contemporary public and political support for ICT implementation schools has not been matched by educational results. Krumsvik offers several possible scenarios for a more productive pathway forward.

A study from Brazil by de Fátima d'Assumpção Castro and Alves (2007) examined conditions surrounding the installation and use of ICT in a mid-sized technologically advanced municipality. Although the installations they studied at the time superficially appeared sophisticated and modern, their application to practice revealed important deficiencies. Installation designs (e.g., static computer labs) reinforced outmoded assumptions about teaching; moreover, installations were not properly maintained or supported with skilled technical personnel.

In a particularly important analysis commissioned by the World Bank, Ottevanger et al. (2007) suggest that a significant constraint to the productive infusion of ICTs into secondary sub-

Saharan math and science curriculum rests with the relative unattractiveness of teacher training in comparison with other university-level courses of study. As a result, according to this study, "teacher education programs attract the weakest students entering higher education, that is, students who cannot be admitted to medicine, engineering, and other more attractive options." (Page xii).

Moreover, the World Bank study suggests that teacher education programs are deemed excessively academic and remote from the real challenges confronting classrooms. Finally, ICT needs to be better developed as a vehicle for the ongoing development and support of practicing teachers. In other words, ICT techniques should be embedded in the education programs that prepare teachers to integrate ICT into their own classroom teaching. The following countries are included in the study: Botswana, Burkina Faso, Ghana, Namibia, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zimbabwe.

Evolving approaches in the field

A variety of themes and practices emerge from the current literature. For example, based on a qualitative/quantitative research study from Israel, Barak (2006) strongly advocates for teacher education programs that embed replicable models for instructional design and teaching throughout the curricula that students experience. Olakulehin (2007) addresses similar issues from an African perspective. The developing world, he suggests, needs to focus on sustainability, resource adequacy, and on-going professional development in order to assure the effective development of ICTs in Nigerian schools. Teacher education should reflect these principles.

Carr and Chambers (2006) offer program strategies to promote the collective professionalism upon which effective ICT curriculum integration depends. Consonant with the World Bank study mentioned above, Graham (2008) suggests that classroom teachers tend to develop ICT strategies that reflect the ways in which they, themselves, have learned to use technology. Thus, the technology education of preparing teachers should include activities anchored in play and gaming if learning-by-play is to be included in the ICT-integrated teaching agenda of novice professionals about to enter the classroom.

In a research synthesis of technology-mediated in-service teacher mentoring initiatives, Gentry et al. (2008) report mixed results. Although teacher outcomes for certain technology-enhanced mentoring initiatives varied across projects, participant perspectives were generally reported as positive. Little evidence is shown, however, of changes in participant attitudes toward teaching or change in instructional practice. Moreover, technology-enhanced mentoring did not seem to correlate to improved instructional practice or to elevations in measured student performance.

Recent recommendations from “Becta” (formerly labeled the British Educational Communications and Technology Agency) by Haydn and Burton (2007) urge that ICT teacher preparation programs should focus explicitly on the disciplinary subject areas to be taught. This Becta report focuses particularly on science and history teaching. A similar perspective is reflected by Ozen (2008) who reports on in-service teacher education in Turkey. He affirms that applicants for these programs should be carefully screened before in-service training begins and that such programs should be carefully evaluated afterwards in terms of their original goals.

In 2008, Lin reported from the United States that math teachers-in-training who have incorporated Web-based instruction into their ICT training subsequently demonstrate more positive attitudes about ICT-supported teaching, and that these more positive attitudes correlate to higher levels of instructional computer competency. From Taiwan, Wu et al. (2008) report that practicing science teachers' perceived computer self-efficacy influences their intentions about integrating technology into their curricula. Silla et al. (2008) have identified eLearning resources to support teachers of disabled children. They suggest that educational institutions in developing countries need to recognize the specialized support available to special education teachers in the developed world so that they might replicate such practice locally.

"Hot" topics in this field

The current research base on ICTs in teacher education reflects its precursor literature, focusing on a series of pressing issues. For example, the following questions recur frequently in the literature on ICT practice in teacher education:

1. What is the relative effectiveness of teacher education that teaches ICT as separate subject matter versus that which embeds ICT throughout the curriculum?
2. What constitutes "best practice" in pre-service and in-service teacher education?
3. How is teacher education for ICT transformed into actual classroom practice?
4. What influences do school conditions (as distinct from teacher education as such) have on the effectiveness of ICT integration in the curriculum?
5. What are the particular needs of teacher education for ICT in the developing world?

Research gaps suggesting further investigation

From the literature reported above, further research appears to be needed across a variety of dimensions. Research focusing on the particular needs of teacher education in the developing world seems to be particularly scant. Deeper research is needed on the relationship between teacher education and effective ICT integration in schools. From a more practical viewpoint, a deeper knowledge base on "best practice" in teacher education would inform better program development targeted on the needs of education's ultimate clients: elementary and secondary school students.

Absent from the current research base is information about optimizing the contributions of institutional stakeholders of ICT integration. For example, what are the most appropriate roles for local school administrations, national and regional governments, the private sector, NGOs and professional associations in providing for best practices possible? What strategies exist to create robust programmatic bridges between the higher education programs that prepare teachers and the schools that ultimately hire them? What principles particularly drive effective pre-service teacher preparation as distinct from practices that advance in-service professional development?

References

Barak, M. (2006). Instructional principles for fostering learning with ICT: teachers' perspectives as learners and instructors, *Education and Information Technologies, 11*(2), 121-135.

Buettner, Y. (2006). Teaching teachers to teach ICT integration, *Education and Information Technologies, 11*(3), 257-268.

Carr, N. and Chambers, D. P. (2006). Cultural and organisational issues facing online learning communities of teachers, *Education and Information Technologies, 11*(3), 269-283

de Fátima D'Assumpção Castro, M. and Alves, L. A. (2007). The implementation and use of computers in education in Brazil: Niterói city/Rio de Janeiro, *Computers & Education, 49*(4), 1378-1386.

Gentry, L., Denton, C., & Kurz, T. (2008, July 1). Technologically-Based Mentoring Provided to Teachers: A Synthesis of the Literature. *Journal of Technology and Teacher Education, 16*(3), 339-373.

Graham, L. (2008). Teachers Are Digikids Too: The Digital Histories and Digital Lives of Young Teachers in English Primary Schools, *Literacy, 42*(1), 10-18.

Kim, M. K., Sharp, J. M. and Thompson, A. D., (1998). Effects of integrating problem-solving, interactive multimedia and constructivism in teacher education, *Journal of Educational Computing Research, 19*(10), 83-108.

Krumsvik, R. (2008). The view of knowledge and the new national curriculum in Norway. *US-China Education Review, 5*(7), 13-28. Retrieved from: http://www.teacher.org.cn/doc/ucedu200807/ucedu20080702.pdf

McKinney, M. (1998). Pre-service teachers' electronic portfolios: Integrating technology, self-assessment and reflection. *Teacher Education Quarterly, 25*(1), 85-103.

Olakulehin, F. K. (2007). Information and communication technologies in teacher training and professional development in Nigeria. *Turkish Online Journal of Distance Education, 8*(1) Retrieved from http://tojde.anadolu.edu.tr/tojde25/pdf/article_11.pdf.

Ottevanger, W., Akker, J. v. d., & de Feiter, L. (2007). *Developing science, mathematics, and ICT education in sub-saharan africa : Patterns and promising practices*. Washington, D.C.: World Bank Africa Region Human Development Department.

Ozen, R. (2008). Inservice training (INSET) programs via distance education: Primary school teachers' opinions. *Turkish Online Journal of Distance Education, 8*(2). Retrieved from http://tojde.anadolu.edu.tr/tojde26/

Silla, V., & Hobbs, T. (2008). *Culturally accessible E-learning materials for international special educators*. International Conference on Learning, (Chicago: 15th, University of Chicago, June 3-6, 2008).

Strudler, N., McKinney, M., Jones, W. P. and Quinn, L. F. (1999). First-year teachers' use of technology: Preparation, expectations and realities. *Journal of Technology and Teacher Education, 7*(2), 115-130.

Topp, N., (1996). Preparation to use technology in the classroom: Opinions by recent graduates. *Journal of Computing in Teacher Education, 12*(4), 24-27.

Wu, W., Chang, H., & Guo, C. (2008). An empirical assessment of science teachers' intentions toward technology integration. *Journal of Computers in Mathematics and Science Teaching, 27*(4), 499-520.

Educational Content and ICT

Overview

The relationship between ICT use and disciplinary content reveals a robust literature base on actual educational practice with a much less definitive research foundation on the results of such practice. Moreover, search strategies using keywords and terms designed to generate reports on educational content yielded outcomes also germane to the other themes derived from the GeSCI Terms of Reference, such as Teacher Education, Educational Leadership, and Efficacy Evaluation.

Nevertheless, resources were found across a variety of subject areas and levels of schooling. Partly due to the search terms employed, a relatively greater number were revealed in language education, mathematics and science. Several citations focused on ICT use for preschool and early childhood education. This is noteworthy because conventional wisdom suggests that ICTs are antithetical to the exemplary practice of early childhood education.

Challenges and constraints impacting progress

Because the nature of educational "content" is changing so rapidly, teachers of all subject area disciplines need to focus as much on skills of research and scholarly discretion as on content itself. Education can no longer rely on printed textbooks as single-source content repositories for whole courses of study. Whether educators like it or not, learners will be exposed to alternative perspectives and information sources. If this is true, educators will also need to tackle issues of learner safety and privacy. In many countries, legislation and policy have been adopted to assure student and teacher privacy and the protection of intellectual property, but the technology is changing faster than the measures taken to address it. Thus, a sharper focus on the research effort in these areas will help publishers and policymakers keep up with events. Although it is beyond the scope of this investigation, these issues clearly have implications for academic publishing. Future research is needed to ensure stability in the emerging electronic world of content creation and distribution.

Evolving approaches in the field

In a meta-analysis of eleven studies, Abraham (2008) provides evidence of effective ICT supported language (L2) learning, particularly related to vocabulary development and the promotion of second-language conversational fluency. Basharina et al., (2008), however, caution that ICT supported cross-border tele-collaborations (in Mexico and Canada) can produce counterproductive tensions if cultural differences and expectations are not carefully understood and taken into account prior to project launch. (See also Chadwick and Valenzuela, 2007, in the section on “ICT Leadership and Management.”) This perspective is supported by McKloskey et al, (2008) who describe an inter-governmental agreement between the United States and China supporting L2 online teaching strategies for citizens of both nations to acquire language skills of the other country. Evaluation of this project suggests the importance of incorporating cross-

cultural awareness into the online learning activities. This report also stresses the value of productive integration between pedagogical designs and technical development.

Several observers describe the efficacy of wireless SMS text and technologies to support the more modest goals of L2 vocabulary development (Cavus and Ibrahim, 2008; Chen and Chung, 2008; Lu, 2008; Aderinoye, 2008). From Brazil, de Almeida-Soares (2008) describes the constructive use of blogs to promote English as a Foreign Language (EFL) instruction for secondary students.

Balajthy (2007) perceives ICT as a particularly powerful for authentic student diagnosis and assessment in the literacy education. According to Balajthy, networked computers hold unique potential for supporting the development of student portfolios and teacher record-keeping. Based on a mix of survey and case study techniques, this author reports that students require significantly more support and prior training than what is typically offered in order to succeed. Like Basharina, she strongly recommends extensive collegial communication to support implementation. The potential of ICTs for teaching language and literacy is not confined to the major, living languages of the world. Oyelami (2008) describes the use of computers with standalone software products supporting language instruction in a low-incidence native tongue (Igbo) at risk of disappearance.

Yarnall et al. (2007) have shown that handheld devices can support "writing across the curriculum" efforts throughout a school district. In such cases, devices support essential learning activities including networked collaboration. Yarnall's report builds on an earlier study describing the use of handheld devices in science education. Her work strongly promotes the use of constructivist, student-centered instructional strategies. She makes an interesting distinction between technology-driven "automation" versus "information." If the ultimate benefit of ICT is only to automate, she feels that it is bound to fail. At a lower level of technological sophistication, Aderinoye (2008) advocates the use of traditional tools such as radio and television to support literacy education in resource-poor countries. Like several other studies in this report, Aderinoye indicates a strong relationship between effective teacher education and robust classroom implementation.

Small, handheld devices are not only being used for instruction but also to support teacher education with communication tools and the development of content. For example, Wishart (2008) presents findings from project that equipped training teachers in modern foreign language education with PDAs. Seven trainees were loaned PDAs for the duration of a course. End-of-year interviews yielded mixed results. Users tended to default to more traditional technology practices rather than internalizing and continuing the use of PDAs. Michael Hardy (2008) discusses a middle school project called Technology in Math Education (TIME), noting the importance of effective teacher education in advancing the integration of ICT into the school mathematics curriculum. A comparative analysis of teacher mathematics practice via a case study by Crisan et al. (2007) found that effective instructional practice in the UK depended on a combination of pedagogical skill and ICT knowledge.

The literature on the application of ICT in mathematics education is extensive. The World Bank has published a particularly important study regarding the status of math and science education

in Sub-Saharan Africa. In this report's earlier discussion about Teacher Education, Ottevanger et al. identified serious deficiencies in leadership, teacher training, and classroom implementation. Franklin et al. (2008) offer a case study evaluating the use of iPod Touch devices to advance middle school math teaching. Benefits cited by these researchers include student access to materials in various media beyond the constraints of classroom time and place. In an attempt to break the tradition of curricular fragmentation typical of much contemporary math teaching, Teasdale (2008) describes a British project that applies ICT to the promotion of authentic, outcomes-led, problem-based, learner-centered mathematics education. She suggests that ICT should be a driver of curricular transformation rather than simply a more efficient tool of transmission.

Two studies outline the use of tablet PCs in the mathematics curriculum. Kerawalla et al. (2007) describe the use of these machines to promote numeracy in the lower primary grades. A homework resource-sharing software system was designed to integrate the learning efforts pursued at school with those undertaken at home. Qualitative study results on this project suggest improvement in children's numeracy skills. The results also point to elevated parental engagement. At the undergraduate university level, Fister et al (2008) also depict the power of tablet PCs to improve mathematics instruction.

This literature review produced several reports linking ICT to the education of very young children. For example, Johanson et al. (2008) discuss the implications of ICT for pre-school literacy. In this American case, technology activities for classroom integration are described, as are telecommunication strategies between school and home. According to a program evaluation, learner literacy skills improved as did higher order technological tool skills. Mainstream and disabled learners seem to benefit equally. In Australia, Zevenbergen and Logan (2008) describe wide demographic variations in the home computer access. These findings are based on a parent survey of 4-5 year olds.

O'Hara (2008) recounts successful ICT practices for teaching social skills to this same age group. He cautions, however, that technology is not appropriate for all young children; nor is it a substitute for skilled pedagogy. Research on the use of technology with this age group continues to emerge in 2009. Levy (2009) suggests that young children already come to preschool equipped with sophisticated digital skills and need to have those skills reinforced while in school. Parette et al. (2009) describe "best technology practices" in literacy education for early childhood learners.

Between 2006 and 2008, other disciplinary subject areas appeared to receive less attention than literacy and mathematics. Zucker and Hug (2008) describe a one-to-one laptop to student ratio applied to secondary-level physics teaching in an American charter school serving low income children. Laptops are used in a variety of networked and stand-alone ways. The mixed-mode qualitative and quantitative evaluation of these laptop-specific ICT strategies demonstrated solid project success. Bennett and Fessenden (2006) describe the use of read/write Web tools to promote citizenship education in the elementary grades. Examples include the use of Web 2.0 networked composition tools for learners to contact elected political representatives, and discussion boards for sharing peer perspectives about public issues.

Literature on the potential of mobile technologies is emerging. In higher education, Kulkuska and Shield (2008) see the potential of mobile learning as a means for advancing curriculum from simple content distribution toward sophisticated interactive collaboration. Although this report focuses specifically on language learning, it could apply to instructional improvement in any discipline. These researchers emphasize that effective instructional design must account for the personal and social needs of the target learners. The newer mobile learning tools, however, raise some red flags. Weller et al., (2008) report concerns about podcasting, for example, as a "push" technology distributing content but enabling very little communication about that content. They describe strategies to integrate mobile technology seamlessly with other tools that promote communications and production related to primary-grade curricular field trips.

"Hot" topics in this field

The following broad topics emerge from this preliminary thematic review:

1. ICTs and second-language education,
2. ICTs and education in mathematics and science,
3. ICTs and education for early childhood and pre-school,
4. The contribution of m-learning strategies to support content development in a variety of disciplines and educational levels,
5. ICTs as tools for learner diagnosis and assessment,
6. Lack of resources and investment to support and evaluate effective ICT implementation.

Research gaps suggesting further investigation

Work conducted to date in this study suggests the need for much more research and development in the application of ICT to science education content at all levels of schooling. Although some resources emerging from this search discussed the potential for m-learning in the distribution of content, this conversation needs more attention, especially m-learning's role as a tool for productive communication about content.

When the literature addresses "content," it tends to do so in a traditional manner. However, it might be argued that the nature of educational "content" has changed dramatically as a result of the contemporary digitization of all media types. Until recently, educational content primarily rested in the domain of textbook publishers. Today, content is available from countless sources representing diverse perspectives. Its authenticity and objectivity demands far more scrutiny, implying a deeper and greater range of discretionary skill for teachers and learners alike.

References

Abraham, L. B. (2008). Computer-mediated glosses in second language reading comprehension and vocabulary learning: A meta-analysis. *Computer Assisted Language Learning, 21*(3), 199-226.

Aderinoye, R. (2008). Literacy and communication technologies: Distance education strategies for literacy delivery. *International Review of Education, 54,* 605-626.

Balajthy, E. (2007). Technology and current Reading/Literacy assessment strategies. *Reading Teacher, 61*(3), 240-247.

Basharina, O., Guardado, M., & Morgan, T. (2008). Negotiating differences: Instructors' reflections on challenges in international telecollaboration. *Canadian Modern Language Review, 65*(2), 275-305.

Bennett, L., & Fessenden, J. (2006). Citizenship through online communication. *Social Education, 70*(3), 144-146.

Cavus, N., & Ibrahim, D. (2008). *A mobile tool for learning English words*. Lefke, North Cyprus: International Conference on Electrical and Computer Systems, November 27-28, 2008.

Chen, C. M., & Chung, C. J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle. *Computers & Education, 51*(2), 624-645.

Crisan, C., Lerman, S., & Winbourne, P. (2007). Mathematics and ICT: A framework for conceptualising secondary school mathematics teachers' classroom practices. *Technology, Pedagogy and Education, 16*(1), 21-39.

De Almeida-Soares S. (2008). Understanding class blogs as a tool for language development. *Language Teaching Research, 12*(4), 517-533.

Fister, K. R., & McCarthy, M. L. (2008). Mathematics instruction and the tablet PC. *International Journal of Mathematical Education in Science and Technology, 39*(3), 285-292.

Franklin, T., & Peng, L. (2008). Mobile math: Math educators and students engage in mobile learning. *Journal of Computing in Higher Education, 20*(2), 69-80.

Hardy, M. (2008). It's TIME for technology: The technology in mathematics education project. *Journal of Computers in Mathematics and Science Teaching, 27*(2), 221-237.

Johanson, J., Bell, C., Daytner, K., & Western Illinois University, Center for Best Practices in Early Childhood Education. (2008). *Evaluating the effectiveness of a technology-based preschool literacy project: A final report of the LitTECH outreach project.* Center for Best Practices in Early Childhood Education.

Kerawalla, L., O'Connor, J., Underwood, J., duBoulay, B., Holmberg, J., Luckin, R., et al. (2007). Exploring the potential of the homework system and tablet PCs to support continuity of numeracy practices between home and primary school. *Educational Media International, 44*(4), 289-303.

Kukulska-Hulme, A., & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. *ReCALL, 20*(3), 271-289.

Levy, R. (2009). "You have to understand words...but not read them": Young children becoming readers in a digital age. *Journal of Research in Reading, 32*(1) 75-91.

Lu, M. (2008). Effectiveness of vocabulary learning via mobile phone. *Journal of Computer Assisted Learning, 24*(6), 515-525.

McCloskey, M. L., Thrush, E. A., Wilson-Patton, M., & Kleckova, G. (2008). Developing English language curriculum for online delivery. *CALICO Journal, 26*(1), 182-203.

O'Hara, M. (2008). Young children, learning and ICT: A case study in the UK maintained sector. *Technology, Pedagogy and Education, 17*(1), 29-40.

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

Ottevanger, W., Akker, J. v. d., & de Feiter, L. (2007). *Developing science, mathematics, and ICT education in sub-Saharan Africa : Patterns and promising practices.* Washington, D.C.: World Bank Africa Region Human Development Department.

Oyelami, O. M. (2008). Development of Igbo language e-learning system. *Turkish Online Journal of Distance Education, 9*(4), 39-52.

Parette, H. P., Hourcade, J. J., Dinelli, J. M.; Boeckmann, N. M. (2009). Using "Clicker 5" to enhance emergent literacy in young learners. *Early Childhood Education Journal, 36*(4), 355-363

Teasdale, R. (2008). Outcome-led and process-led teaching. *Mathematics teaching incorporating micromath, (210)*, 3-7.

Weller, A. M., Bickar, J. C., & McGuinness, P. (2008). Making field trips podtastic! Use of handheld wireless technology alleviates isolation and encourages collaboration. *Learning & Leading with Technology, 35*(6), 18-21.

Yang, Y. C., & Chan, C. (2008). Comprehensive evaluation criteria for English learning websites using expert validity surveys. *Computers & Education, 51*(1), 403-422.

Yarnall, L., Carriere, S., Stanford, T., Manning, C., & Melton, B. (2007). What happens to "writing across the curriculum" with handheld devices? *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 26-29.

Yashima, T., & Zenuk-Nishide, L. (2008). The impact of learning contexts on proficiency, attitudes, and L2 communication: Creating an imagined international community. *System:*

An International Journal of Educational Technology and Applied Linguistics, 36(4), 566-585.

Zevenbergen, R., & Logan, H. (2008). Computer use by preschool children: Rethinking practice as digital natives come to preschool. *Australian Journal of Early Childhood, 33*(1), 37-44.

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.

References Generated by Controlled Vocabulary for GeSci Meta-analysis

Abraham, L. B. (2008). Computer-mediated glosses in second language reading comprehension and vocabulary learning: A meta-analysis [Electronic version]. *Computer Assisted Language Learning, 21*(3), 199-226.

Aczel, J. C., Peake, S. R., & Hardy, P. (2008). Designing capacity-building in E-learning expertise: Challenges and strategies [Electronic version]. *Computers & Education, 50*(2), 499-510.

Aderinoye, R. (2008). Literacy and communication technologies: Distance education strategies for literacy delivery [Electronic version]. *International Review of Education, 54*, 605-626.

Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2008). School leadership and information communication technology. *Turkish Online Journal of Educational Technology, 7*(4). Retrieved from http://eric.ed.gov.

Akhter, Z. (2008). Quality assurance in secondary education program of Bangladesh Open University: Present status and challenges. *Turkish Online Journal of Distance Education, 9*(2). Retrieved from http://eric.ed.gov.

Amiel, T. (2006). Mistaking computers for technology: Technology literacy and the digital divide [Electronic version]. *AACE Journal, 14*(3), 235-256. Retrieved from Ebscohost ERIC database.

Anthony, T. D., & Kritsonis, W. A. (2006). A mixed methods assessment of the effectiveness of strategic EMentoring in improving the self-efficacy and persistence (or retention) of alternatively certified novice teachers within an inner city school district [Electronic version]. *National Journal for Publishing and Mentoring Doctoral Student Research, 4*(1). Retrieved from http://eric.ed.gov.

Bai, H., & Ertmer, P. (2008). Teacher educators' beliefs and technology uses as predictors of preservice teachers' beliefs and technology attitudes. *Journal of Technology and Teacher Education, 16*(1), 93-112. Retrieved from Ebscohost Eric database.

Balajthy, E. (2007). Technology and current Reading/Literacy assessment strategies. *Reading Teacher, 61*(3), 240-247. Retrieved from Ebscohost Eric database.

Banyard, P., Underwood, J., & Twiner, A. (2006). Do enhanced communication technologies inhibit or facilitate self-regulated learning [Electronic version]? *European Journal of Education, 41*, 473-489.

Banza, N. N. (2006). Are the rural schools of the Democratic Republic of Congo ready for the $100 laptop? *Turkish Online Journal of Educational Technology, 5*(4). Retrieved from http://eric.ed.gov.

Barak, M. (2006). Instructional principles for fostering learning with ICT: Teachers' perspectives as learners and instructors [Electronic version]. *Education and Information Technologies, 11*(2), 121-135.

Barbour, M. K. (2007). Portrait of rural virtual schooling. *Canadian Journal of Educational Administration and Policy,* (59), 1-21. Retrieved from http://eric.ed.gov.

Barron, A. E., & Harmes, J. C. (2006). Authentic instruction in laptop classrooms: Sample lessons that integrate type II applications. *Computers in the Schools, 22*, 119-130. Retrieved from Ebscohost Eric database.

Basharina, O., Guardado, M., & Morgan, T. (2008). Negotiating differences: Instructors' reflections on challenges in international telecollaboration. *Canadian Modern Language Review, 65*(2), 275-305. Retrieved from Ebscohost Eric database.

Batchelor, S., & Norrish, P. (2006). *Framework for the assessment of ICT pilot projects: Beyond monitoring and evaluation to applied research.* Retrieved from http://www.infodev.org/en/Publication.9.html.

Becker, J. D. (2006). Digital equity in education: A multilevel examination of differences in and relationships between computer access, computer use and state-level technology policies. *Education Policy Analysis Archives, 15*(3), 1-38. Retrieved from http://epaa.asu.edu/epaa/v15n3/.

Beers, P. J., Boshuizen, H. P. A., Kirschner, P. A., Gijselaers, W., & Westendorp, J. (2008). Cognitive load measurements and stimulated recall interviews for studying the effects of information and communications technology. *Educational Technology Research and Development, 56*(3), 309-328. Retrieved from Ebscohost Eric database.

Beisser, S. R. (2006). An examination of gender differences in elementary constructionist classrooms using Lego/Logo instruction. *Computers in the Schools, 22*, 7-19. Retrieved from http://hdl.handle.net/2092/411.

Bennett, L., & Fessenden, J. (2006). Citizenship through online communication. *Social Education, 70*(3), 144-146. Retrieved from Ebscohost Eric database.

Berman, S. D. (2008). 65. ICT-based distance education in South Asia. *International Review of Research in Open and Distance Learning, 9*(3), 1-6. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/581/1131.

Bisaso, R., Kereteletswe, O., Selwood, I., & Visscher, A. (2008). The use of information technology for educational management in Uganda and Botswana [Electronic version]. *International Journal of Educational Development, 28*(6), 656-668.

Blaisdell, M. (2006). Educational gaming: All the right MUVEs. *T.H.E.Journal, 33*(14), 28-38. Retrieved from http://www.thejournal.com/articles/19173_1.

Bottino, R. M., Ferlino, L., Ott, M., & Tavella, M. (2007). Developing strategic and reasoning abilities with computer games at primary school level [Electronic version]. *Computers & Education, 49*(4), 1272-1286.

Bottino, R. M., & Ott, M. (2006). Mind games, reasoning skills, and the primary school curriculum [Electronic version]. *Learning, Media & Technology, 31*(4), 359-375.

Buettner, Y. (2006). Teaching teachers to teach ICT integration—T3 [Electronic version]. *Education and Information Technologies, 11*(3), 257-268. Retrieved from Ebscohost Eric database.

Burns, K., & Polman, J. (2006). The impact of ubiquitous computing in the internet age: How middle school teachers integrated wireless laptops in the initial stages of implementation. *Journal of Technology and Teacher Education, 14*(2), 363-385. Retrieved from Ebscohost Eric database.

Calandra, B., Barron, A. E., & Thompson-Sellers, I. (2008). Audio use in E-learning: What, why, when, and how? *International Journal on E-Learning, 7*(4), 589-601. Retrieved from Ebscohost Eric database.

Carnoy, M., Gove, A. K., Loeb, S., Marshall, J. H., & Socias, M. (2008). How schools and students respond to school improvement programs: The case of Brazil's PDE [Electronic version]. *Economics of Education Review, 27*(1), 22-38.

Carr, N., & Chambers, D. (2006). Cultural and organisational issues facing online learning communities of teachers [Electronic version]. *Education and Information Technologies, 11*(3), 269-282.

Cavus, N., Bicen, H., & Akcil, U. (2008). The opinions of information technology students on using mobile learning. *Paper Presented at the International Conference on Educational Sciences (ICES),* Famagusta, Cyprus. Retrieved from http://eric.ed.gov.

Cavus, N., & Ibrahim, D. (2008). A mobile tool for learning english words. *Paper presented at the International Conference on Electrical and Computer Systems (ICES),* Lefke, North Cyprus. Retrieved from http://eric.ed.gov.

Center for Digital Education (2008). *Online learning policy and practice survey: A survey of the States.* Center for Digital Education. Retrieved from http://eric.ed.gov.

Chadwick, C., & Valenzuela, S. (2008). Culture, change, and educational improvement. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 48*(4), 27-36. Retrieved from Ebscohost Eric database.

Chandra, V., & Lloyd, M. (2008). The methodological nettle: ICT and student achievement [Electronic version]. *British Journal of Educational Technology, 39*(6), 1087-1098.

Chang, I. H., Chin, J. M., & Hsu, C. (2008). Teachers' perceptions of the dimensions and implementation of technology leadership of principals in Taiwanese elementary schools. *Educational Technology & Society, 11*(4), 229-245. Retrieved from Ebscohost Eric database.

Charalambous, K., & Ioannou, I. (2008). The attitudes and opinions of Cypriot primary teachers about the use of the internet for their professional development and as an educational tool. *Learning, Media and Technology, 33*(1), 45-57. Retrieved from Ebscohost Eric database.

Chen, C. M., & Chung, C. J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle. *Computers & Education, 51*(2), 624-645. Retrieved from Ebscohost Eric database.

Childs, A., Twidle, J., Sorensen, P., & Godwin, J. (2007). Trainee teachers' use of the internet--opportunities and challenges for initial teacher education. *Research in Science & Technological Education, 25*(1), 77-97. Retrieved from Ebscohost Eric database.

Christensen, R., & Knezek, G. (2007). Pathway for preparing tomorrow's teachers to infuse technology. *Computers in the Schools, 23*, 1-21. Retrieved from Ebscohost Eric database.

Clausen, J. M., Britten, J., & Ring, G. (2008). Envisioning effective laptop initiatives. *Learning & Leading with Technology, 36*(1), 18-22. Retrieved from Ebscohost Eric database.

Coca, V., Allensworth, E. M., & Consortium on Chicago, S. R. (2007). *Trends in access to computing technology and its use in Chicago public schools, 2001-2005.* Consortium on Chicago School Research. Retrieved from http://eric.ed.gov.

Cohen, M. T., Pelligrino, J. W., Schmidt, D. A., & Schultz, S. (2007). Sustaining technology integration in teacher education. *Action in Teacher Education, 29*(3), 75-87. Retrieved from Ebscohost Eric database.

Consortium for School Networking. (2008). *CoSN K12 open technologies implementation study #3. Moodle: An open learning content management system for schools.* Consortium for School Networking. Retrieved from http://eric.ed.gov.

Crisan, C., Lerman, S., & Winbourne, P. (2007). Mathematics and ICT: A framework for conceptualising secondary school mathematics teachers' classroom practices. *Technology, Pedagogy and Education, 16*(1), 21-39. Retrieved from Ebscohost Eric database.

Dalgarno, N., & Colgan, L. (2007). Supporting novice elementary mathematics teachers' induction in professional communities and providing innovative forms of pedagogical content knowledge development through information and communication technology [Electronic version]. *Teaching and Teacher Education: An International Journal of Research and Studies, 23*(7), 1051-1065.

Daly, T. (2008). School culture and values-related change: Towards a critically pragmatic conceptualization [Electronic version]. *Irish Educational Studies, 27*(1), 5-27.

Davis, T., Fuller, M., Jackson, S., Pittman, J., & & Sweet, J. (2007). *A National consideration of digital equity.* International Society for Technology in Education (ISTE). Retrieved from http://eric.ed.gov.

Dawson, K. (2006). Teacher inquiry: A vehicle to merge prospective teachers' experience and reflection during curriculum-based, technology-enhanced field experiences. *Journal of Research on Technology in Education, 38*(3), 265-292. Retrieved from Ebscohost Eric database.

de Fatima D'Assumpcao Castro, M., & Alves, L. A. (2007). The implementation and use of computers in education in Brazil: Niterói city/Rio de Janeiro [Electronic version]. *Computers & Education, 49*(4), 1378-1386.

de Almeida Soares, D. (2008). Understanding class blogs as a tool for language development. *Language Teaching Research, 12*(4), 517-533. Retrieved from Ebscohost Eric database.

Drenoyianni, H. (2006). Reconsidering change and ICT: Perspectives of a human and democratic education [Electronic version]. *Education and Information Technologies, 11*(3), 401-413.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively [Electronic version]? *Computers & Education, 51*(1), 187-199.

Drexler, W., Baralt, A., & Dawson, K. (2008). The teach web 2.0 consortium: A tool to promote educational social networking and web 2.0 use among educators. *Educational Media International, 45*(4), 271-283. Retrieved from Ebscohost Eric database.

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. Retrieved from Ebscohost Eric database.

Duran, M., Fossum, P. R., & Luera, G. R. (2007). Technology and pedagogical renewal: Conceptualizing technology integration into teacher preparation. *Computers in the Schools, 23*, 31-54. Retrieved from Ebscohost Eric database.

Dwyer, J. (2007). Computer-based learning in a primary school: Differences between the early and later years of primary schooling. *Asia-Pacific Journal of Teacher Education, 35*(1), 89-103. Retrieved from Ebscohost Eric database.

Elstad, E. (2006). Understanding the nature of accountability failure in a technology-filled, laissez-faire classroom: Disaffected students and teachers who give in. *Journal of Curriculum Studies, 38*(4), 459-481. Retrieved from Ebscohost Eric database.

Eteokleous, N. (2008). Evaluating computer technology integration in a centralized school system [Electronic version]. *Computers & Education, 51*(2), 669-686.

Evoh, C. J. (2007). Collaborative partnerships and the transformation of secondary education through ICTs in South Africa. *Educational Media International, 44*(2), 81-98. Retrieved from Ebscohost Eric database.

Ferdig, R. E., Coutts, J., DiPietro, J., Lok, B., & Davis, N. (2007). Innovative technologies for multicultural education needs [Electronic version]. *Multicultural Education & Technology Journal, 1*(1), 47-63.

Fister, K. R., & McCarthy, M. L. (2008). Mathematics instruction and the tablet PC. *International Journal of Mathematical Education in Science and Technology, 39*(3), 285-292. Retrieved from Ebscohost Eric database.

Fletcher, D. (2006). Technology integration: Do they or don't they? A self-report survey from PreK through 5th grade professional educators. *AACE Journal, 14*(3), 207-219. Ebscohost Eric database.

Forgasz, H. (2006). Teachers, equity, and computers for secondary mathematics learning [Electronic version]. *Journal of Mathematics Teacher Education, 9*(5), 437-469.

Franklin, C. (2007). Factors that influence elementary teachers' use of computers. *Journal of Technology and Teacher Education, 15*(2), 267-293. Retrieved from http://eric.ed.gov.

Franklin, T., & Peng, L. (2008). Mobile math: Math educators and students engage in mobile learning [Electronic version]. *Journal of Computing in Higher Education, 20*(2), 69-80.

Fry, S. W. (2006). A technology supported induction network for rural student teachers. *Rural Educator, 27*(2), 1-10. Retrieved from Ebscohost Eric database.

Gentry, L. B., Denton, C. A., & Kurz, T. (2008). Technologically-based mentoring provided to teachers: A synthesis of the literature. *Journal of Technology and Teacher Education, 16*(3), 339-373. Retrieved from Ebscohost Eric database.

Girasoli, A. J., & Hannafin, R. D. (2008). Using asynchronous AV communication tools to increase academic self-efficacy [Electronic version]. *Computers & Education, 51*(4), 1676-1682.

Goktas, Y., Yildirim, Z., & Yildirim, S. (2008). A review of ICT related courses in pre-service teacher education programs. *Asia Pacific Education Review, 9*(2), 168-179. Retrieved from Ebscohost Eric database.

Gorder, L. M. (2008). A study of teacher perceptions of instructional technology integration in the classroom. *Delta Pi Epsilon Journal, 50*(2), 63-76.

Graham, L. (2008). Teachers are digikids too: The digital histories and digital lives of young teachers in English primary schools. *Literacy, 42*(1), 10-18. Retrieved from Ebscohost Eric database.

Grimes, D., & Warschauer, M. (2008). Learning with laptops: A multi-method case study. *Journal of Educational Computing Research, 38*(3), 305-332. Retrieved from Ebscohost Eric database.

Groff, J., & Haas, J. (2008). Web 2.0: Today's technology, tomorrow's learning. *Learning & Leading with Technology, 36*(1), 12-15. Retrieved from Ebscohost Eric database.

Groth, L. A., Dunlap, K. L., & Kidd, J. K. (2007). Becoming technologically literate through technology integration in PK-12 preservice literacy courses: Three case studies. *Reading Research and Instruction, 46*(4), 363-386. Retrieved from Ebscohost Eric database.

Gulati, S. (2008). Technology-enhanced learning in developing nations: A review. *International Review of Research in Open and Distance Learning, 9*(1), 1-16. Retrieved from http://eric.ed.gov.

Gulbahar, Y. (2008). Improving the technology integration skills of prospective teachers through practice: A case study. *Turkish Online Journal of Educational Technology, 7*(4). Retrieved from http://eric.ed.gov.

Gulbahar, Y. (2007). Technology planning: A roadmap to successful technology integration in schools [Electronic version]. *Computers & Education, 49*(4), 943-956.

Gulbahar, Y., & Guven, I. (2008). A survey on ICT usage and the perceptions of social studies teachers in turkey. *Educational Technology & Society, 11*(3), 37-51. Retrieved from http://www.ifets.info/journals/11_3/4.pdf.

Hardy, M. (2008). It's TIME for technology: The technology in mathematics education project. *Journal of Computers in Mathematics and Science Teaching, 27*(2), 221-237. Retrieved from Ebscohost Eric database.

Harris, J. (2008). One size doesn't fit all: Customizing educational technology professional development--part four--evaluating ETPD designs. *Learning & Leading with Technology, 35*(8), 24-27. Retrieved from Ebscohost Eric database.

Hartley, J. (2007). Teaching, learning and new technology: A review for teachers. *British Journal of Educational Technology, 38*(1), 42-62. Retrieved from Ebscohost Eric database.

Hartnell-Young, E., & Vetere, F. (2008). A means of personalising learning: Incorporating old and new literacies in the curriculum with mobile phones. *Curriculum Journal, 19*(4), 283-292. Retrieved from Ebscohost Eric database.

Haughey, M. (2006). The impact of computers on the work of the principal: Changing discourses on talk, leadership and professionalism. *School Leadership & Management, 26*(1), 23-36. Retrieved from Ebscohost Eric database.

Haydn, T. A., & Barton, R. (2007). Common needs and different agendas: How trainee teachers make progress in their ability to use ICT in subject teaching: Some lessons from the UK [Electronic version]. *Computers & Education, 49*(4), 1018-1036.

Haydn, T., & Barton, R. (2008). "First do no harm": Factors influencing teachers' ability and willingness to use ICT in their subject teaching [Electronic version]. *Computers & Education, 51*(1), 439-447.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223-252.

Hew, K. F., & Hara, N. (2007). Empirical study of motivators and barriers of teacher online knowledge sharing [Electronic version]. *Educational Technology Research and Development, 55*(6), 573-595.

Hoffman, R. (2007). A wireless world: Charles County Public Schools makes wireless universal [Electronic version]. *Technology & Learning, 27*(8), 27-29.

Hohlfeld, T. N., Ritzhaupt, A. D., Barron, A. E., & Kemker, K. (2008). Examining the digital divide in K-12 public schools: Four-year trends for supporting ICT literacy in Florida [Electronic version]. *Computers & Education, 51*(4), 1648-1663.

Holstead, M. S., Spradlin, T. E., & Plucker, J. A. (2008). *Promises and pitfalls of virtual education in the United States and Indiana. Education policy brief. 6*(6), Center for Evaluation and Education Policy, Indiana University. Retrieved from http://eric.ed.gov.

Huang, Y., Kuo, Y., Lin, Y., & Cheng, S. (2008). Toward interactive mobile synchronous learning environment with context-awareness service [Electronic version]. *Computers & Education, 51*(3), 1205-1226.

Huett, J., Moller, L., Foshay, W. R., & Coleman, C. (2008). The evolution of distance education: Implications for instructional design on the potential of the web [Electronic version]. *TechTrends: Linking Research and Practice to Improve Learning, 52*(5), 63-67.

Iske, S., Klein, A., Kutscher, N., & Otto, H. (2008). Young people's internet use and its significance for informal education and social participation. *Technology, Pedagogy and Education, 17*(2), 131-141. Retrieved from Ebscohost Eric database.

Jacob, B. A., Ludwig, J. (2008). *Improving educational outcomes for poor children. discussion.* Institute for Research on Poverty. Retrieved from http://www.closup.umich.edu/research/workingpapers/papers/closup-wp-13-improve-edu-poor.pdf.

James, J. (2008). The digital divide across all citizens of the world: A new concept [Electronic version]. *Social Indicators Research, 89*(2), 275-282.

Jimoyiannis, A., & Komis, V. (2007). Examining teachers' beliefs about ICT in education: Implications of a teacher preparation programme. *Teacher Development, 11*(2), 149-173. Retrieved from Ebscohost Eric database.

Johanson, J., Bell, C., & Daytner, K. (2008). E*valuating the effectiveness of a technology-based preschool literacy project.* Center for Best Practices in Early Childhood Education. Retrieved from http://eric.ed.gov.

Juang, Y., Liu, T., & Chan, T. (2008). Computer-supported teacher development of pedagogical content knowledge through developing school-based curriculum. *Educational Technology & Society, 11*(2), 149-170. Retrieved from http://www.ifets.info/journals/11_2/13.pdf

Judge, S., Puckett, K., & Bell, S. M. (2006). Closing the digital divide: Update from the early childhood longitudinal study. *Journal of Educational Research, 100*(1), 52-60. Retrieved from Ebscohost Eric database.

Kabonoki, S. K. (2008). Access to technology and readiness to use it in learning. *Open Learning, 23*(2), 113-121. Retrieved from Ebscohost Eric database.

Kaestner, R. (2007). Gauging technology costs and benefits. *School Administrator, 64*(5), 28. Retrieved from http://www.aasa.org/publications/saarticledetail.cfm?ItemNumber=8833.

Kafai, Y. B., Nixon, A. S., & Burnam, B. (2007). Digital dilemmas: How elementary preservice teachers reason about students' appropriate computer and internet use. *Journal of Technology and Teacher Education, 15*(3), 409-424. Retrieved from Ebscohost Eric database.

Karagiorgi, Y., & Charalambous, K. (2006). ICT in-service training and school practices: In search for the impact. *Journal of Education for Teaching: International Research and Pedagogy, 32*(4), 395-411. Retrieved from Ebscohost Eric database.

Kay, R. (2006). Addressing gender differences in computer ability, attitudes and use: The laptop effect. *Journal of Educational Computing Research, 34*(2), 187-211. Retrieved from Ebscohost Eric database.

Keengwe, J., Onchwari, G., & Wachira, P. (2008). The use of computer tools to support meaningful learning. *AACE Journal, 16*(1), 77-92. Retrieved Ebscohost Eric database.

Kember, D. (2007). *Reconsidering open and distance learning in the developing world : Meeting students' learning needs*. London; New York: Routledge.

Kerawalla, L., O'Connor, J., Underwood, J., duBoulay, B., Holmberg, J., Luckin, R., et al. (2007). Exploring the potential of the homework system and tablet PCs to support continuity of numeracy practices between home and primary school. *Educational Media International, 44*(4), 289-303. Retrieved from Ebscohost Eric database.

Kim, K., Jain, S., Westhoff, G., & Rezabek, L. (2008). A quantitative exploration of preservice teachers' intent to use computer-based technology. *Journal of Instructional Psychology, 35*(3), 275-287. Retrieved from Ebscohost Eric database.

Kim, P., Miranda, T., & Olaciregui, C. (2008). Pocket school: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America [Electronic version]. *International Journal of Educational Development, 28*(4), 435-445.

Kim, S. W., & Lee, M. G. (2008). Validation of an evaluation model for learning management systems [Electronic version]. *Journal of Computer Assisted Learning, 24*(4), 284-294.

Kinuthia, W. (2008). Another spotlight on the continent: "TechTrends" in Africa [Electronic version]. *TechTrends: Linking Research and Practice to Improve Learning, 52*(4), 21-23.

Klein, J. (2008). Social networking for the K-12 set. *Learning & Leading with Technology, 35*(5), 12-16. Retrieved from http://www.iste.org/Content/NavigationMenu/Publications/LL/LLIssues/Volume_35_2007_2008_/FebruaryNo5/L_L_February_2008.htm; Ebscohost Eric database.

Kok, A. (2008). An online social constructivist tool: A secondary school experience in the developing world. *Turkish Online Journal of Distance Education, 9*(7). Retrieved from http://eric.ed.gov.

Kozma, R. B. (2008). Comparative analysis of policies for ICT in education in *International handbook of information technology in primary and secondary education*. New York: Springer.

Krumsvik, R. (2006). The digital challenges of school and teacher education in Norway: Some urgent questions and the search for answers [Electronic version]. *Education and Information Technologies, 11*(3), 239-256.

Krumsvik, R. J. (2008). From digital divides to digital inequality -- the emerging digital inequality in the Norwegian unitarian school. *US-China Education Review, 5*(9), 1-17. Retrieved from http://eric.ed.gov.

Kukulska-Hulme, A., & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction [Electronic version]. *ReCALL, 20*(3), 271-289.

Kurt, A. A., Coklar, A. N., Kilicer, K., & Yildirim, Y. (2008). Evaluation of the skills of K-12 students regarding the national educational technology standards for students (NETS*S) in turkey. *Turkish Online Journal of Educational Technology, 7*(3). Retrieved from http://eric.ed.gov.

Lai, K., & Pratt, K. (2008). Positive to a degree: The effects of ICT use in New Zealand secondary schools. *Computers in the Schools, 24*, 95-109. Retrieved from Ebscohost Eric database.

Lambert, J., Gong, Y., & Cuper, P. (2008). Technology, transfer, and teaching: The impact of a single technology course on preservice teachers' computer attitudes and ability. *Journal of Technology and Teacher Education, 16*(4), 385-410. Retrieved from Ebscohost Eric database.

LaPrairie, K. N., & Hinson, J. M. (2007). When disaster strikes, move your school online. *Journal of Educational Technology Systems, 35*(2), 209-214. Retrieved from Ebscohost Eric database.

Lee, L. (2008). Focus-on-form through collaborative scaffolding in expert-to-novice online interaction. *Language Learning & Technology, 12*(3), 53-72. Retrieved from http://llt.msu.edu/vol12num3/lee.pdf.

Lee, P. S. N., Leung, L., Lo, V., & Xiong, C. (2008). The perceived role of ICTs in quality of life in three Chinese cities [Electronic version]. *Social Indicators Research, 88*(3), 457-476.

Leonard, L. J., & Leonard, P. E. (2006). Leadership for technology integration: Computing the reality. *Alberta Journal of Educational Research, 52*(4), 212-224. Retrieved from Ebscohost Eric database.

Lesisko, L. J., & Wright, R. J. (2007). *School based leadership for instructional technology*. *Paper presented at the Annual Meeting of the American Educational Research Association*. Chicago, IL. Retrieved from http://eric.ed.gov.

Levin, D., & Arafeh, S. (2002). *The digital disconnect: The widening gap between internet-savvy students and their schools.* Pew Internet & American Life Project. Retrieved from http://www.pewinternet.org/reports/toc.asp?Report=67/.

Levin, T., & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in the classroom: Developmental scenery. *Journal of Technology and Teacher Education, 16*(2), 233-263. Retrieved from Ebscohost Eric database.

Li, X., Atkins, M. S., & Stanton, B. (2006). Effects of home and school computer use on school readiness and cognitive development among head start children: A randomized controlled pilot trial. *Merrill-Palmer Quarterly: Journal of Developmental Psychology, 52*(2), 239-263. Retrieved from http://muse.jhu.edu/journals/merrill-palmer_quarterly/v052/52.2li.pdf.

Liang, J., & Tsai, C. (2008). Internet self-efficacy and preferences toward constructivist internet-based learning environments: A study of pre-school teachers in Taiwan. *Educational Technology & Society, 11*(1), 226-237. Retrieved from http://www.ifets.info/journals/11_1/16.pdf.

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons. *British Journal of Educational Technology, 39*(5), 807-828. Retrieved from Ebscohost Eric database.

Lim, C. P., & Chan, B. C. (2007). Microlessons in teacher education: Examining pre-service teachers' pedagogical beliefs [Electronic version]. *Computers and Education, 48*(3), 474-494.

Lim, W., Lee, Y., & Hung, D. (2008). A prophet never accepted by their own town: A teacher's learning trajectory when using technology. *Asia-Pacific Journal of Teacher Education, 36*(3), 215-227. Retrieved from Ebscohost Eric database.

Lin, C. (2008). A study of pre-service teachers' attitudes about computers and mathematics teaching: The impact of web-based instruction. *International Journal for Technology in Mathematics Education, 15*(2), 45. Retrieved from http://eric.ed.gov.

Livingston, P. (2007). Affording 1:1--knowing your district's technology needs and creating workable solutions are key to a successful 1:1 plan [Electronic version]. *Technology & Learning, 27*(12), 8.

Loomis, S., Rodriguez, J., Tillman, R., & Gunderson, J. (2008). The logic of convergence and uniformity in teacher production. *Teaching Education, 19*(1), 1-10. Retrieved from http://eric.ed.gov.

Lowther, D. L., Inan, F. A., Strahl, J. D., & Ross, S. M. (2008). Does technology integration work when key barriers are removed? *Educational Media International, 45*(3), 195-213. Retrieved from Ebscohost Eric database.

Lu, M. (2008). Effectiveness of vocabulary learning via mobile phone. *Journal of Computer Assisted Learning, 24*(6), 515-525. Retrieved from Ebscohost Eric database.

Marghescu, G., Chicioreanu, T. D., & Marghescu, I. An alternative to the traditional methods in education: M-learning [Electronic version]. Warsaw, Poland. 2410-2414.

McCloskey, M. L., Thrush, E. A., Wilson-Patton, M., & Kleckova, G. (2008). Developing English language curriculum for online delivery. *Calico Journal, 26*(1), 182-203. Retrieved from Ebscohost Eric database.

McDougall, A., & Jones, A. (2006). Theory and history, questions and methodology: Current and future issues in research into ICT in education. *Technology, Pedagogy and Education, 15*(3), 353-360. Retrieved from Ebscohost Eric database.

McHale, T. (2006). One-to-one in Ohio: Part two in our series on one-to-one programs [Electronic version]. *Technology & Learning, 27*(4), 30.

McHale, T. (2007). One-to-one in Alaska: In the remote Alaskan interior, students are reaping the benefits of laptop computing. *Technology & Learning, 27*(8), 24-26. Retrieved from the Gale Science Resource Center database.

McKenney, S. (2008). Shaping computer-based support for curriculum developers [Electronic version]. *Computers and Education. 50*(1), 248-261.

Mcmillan, J. M. (2008). Teachers make it happen: From professional development to integration of augmentative and alternative communication technologies in the classroom. *Australasian Journal of Special Education, 32*(2), 199-211. Retrieved from the Ebscohost Eric database.

McPherson, S., Wang, S., Hsu, H., & Tsuei, M. (2007). New literacies instruction in teacher education [Electronic version]. *TechTrends: Linking Research and Practice to Improve Learning, 51*(5), 24-31.

Mee, A. (2007). E-learning funding for schools: A policy paradox? *British Journal of Educational Technology, 38*(1), 63-71. Retrieved from Ebscohost Academic Search Premier database.

Momanyi, L., Norby, R., & Strand, S. (2006). The need for integration of technology in K-12 school settings in Kenya, Africa. *AACE Journal, 14*(2), 154-177. Retrieved from Ebscohost Eric database.

Monahan, T. (2008). Picturing technological change: The materiality of information infrastructures in public education. *Technology, Pedagogy and Education, 17*(2), 89-101. Retrieved from Ebscohost Eric database.

Morawczynski, O., & Ngwenyama, O. (2007). Unraveling the impact of investments in ict, education and health on development: An analysis of archival data of five West African countries using regression splines. *Education Journal on Education Systems in Developing Countries, 29*(5), 1-15. Retrieved from http://www.ejisdc.org/ojs2/index.php/ejisdc/article/viewFile/352/198.

Motlik, S. (2008). Mobile learning in developing nations. *International Review of Research in Open and Distance Learning, 9*(2), 1-7. Retrieved from http://eric.ed.gov.

Mouza, C. (2008). Learning with laptops: Implementation and outcomes in an urban, under-privileged school. *Journal of Research on Technology in Education, 40*(4), 447-472. Retrieved from Ebscohost Eric database.

Mouzakis, C. (2008). Teachers' perceptions of the effectiveness of a blended learning approach for ICT teacher training. *Journal of Technology and Teacher Education, 16*(4), 459-481. Retrieved from Ebscohost Eric database.

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration [Electronic version]. *Computers & Education, 51*(4), 1523-1537.

Mukama, E., & Andersson, S. B. (2008). Coping with change in ICT-based learning environments: Newly qualified Rwandan teachers' reflections. *Journal of Computer Assisted Learning, 24*(2), 156-166. Retrieved from Ebscohost Eric database.

Muller, J., Sancho Gil, J. M., Hernandez, F., Giro, X., & Bosco, A. (2007). The socio-economic dimensions of ICT-driven educational change [Electronic version]. *Computers & Education, 49*(4), 1175-1188.

Mutton, T., Mills, G., & McNicholl, J. (2006). Mentor skills in a new context: Working with trainee teachers to develop the use of information and communications technology in their subject teaching [Electronic version]. *Technology, Pedagogy and Education, 15*(3), 337-352.

Naevdal, F. (2007). Home-PC usage and achievement in English [Electronic version]. *Computers & Education, 49*(4), 1112-1121.

Norris, C., Shin, N., & Soloway, E. (2007). Educational technology for the mainstream: A call for designing for simplicity and reliability. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 6-9. Retrieved from Ebscohost Eric database.

Norris, C., & Soloway, E. (2008). Handhelds: Getting mobile. *District Administration, 44*(8), 20-24. Retrieved from Ebscohost Eric database.

Oberlander, J., & Talbert-Johnson, C. (2007). Envisioning the foundations of technology integration in pre-service education. *Paper Presented at the Annual Meeting of the Association of Teacher Educators,* San Diego, CA.

O'Hara, M. (2008). Young children, learning and ICT: A case study in the UK maintained sector. *Technology, Pedagogy and Education, 17*(1), 29-40. Retrieved from Ebscohost Eric database.

Olakulehin, F. K. (2007). Information and communication technologies in teacher training and professional development in Nigeria. *Turkish Online Journal of Educational Technology, 8*(1). Retrieved from http://eric.ed.gov.

Oliver, K. M., & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of one-to-one computing. *Educational Media International, 45*(3), 215-229. Retrieved from Ebscohost Eric database.

Oncu, S., Delialioglu, O., & Brown, C. A. (2008). Critical components for technology integration: How do instructors make decisions? *Journal of Computers in Mathematics and Science Teaching, 27*(1), 19-46. Retrieved from Ebscohost Eric database.

Ottevanger, W., Akker, J., & de Feiter, L. (2007). *Developing science, mathematics, and ICT education in sub-saharan Africa : Patterns and promising practices*. Washington, D.C.: World Bank Africa Region Human Development Dept. Retrieved from http://siteresources.worldbank.org/INTAFRREGTOPSEIA/Resources/No.7SMICT.pdf.

Overbaugh, R., & Lu, R. (2008). The impact of a NCLB-EETT funded professional development program on teacher self-efficacy and resultant implementation. *Journal of Research on Technology in Education, 41*(1), 43-61. Retrieved from Ebscohost Eric database.

Oyelami, O. M. (2008). Development of Igbo language E-learning system. *Turkish Online Journal of Distance Education, 9*(4), 39-52. Retrieved from http://eric.ed.gov.

Ozen, R. (2008). Inservice training (INSET) programs via distance education: Primary school teachers' opinions. *Turkish Online Journal of Distance Education, 9*(1), 217. Retrieved from http://eric.ed.gov.

Palozzi, V. J., & Spradlin, T. E. (2006). Educational technology in Indiana: Is it worth the investment? *Education policy brief. 4*(4). Center for Evaluation and Education Policy, Indiana University. Retrieved from http://ceep.indiana.edu/projects/PDF/PB_V4N4_Spring_2006_Education_Technology.pdf.

Park, E., Sinha, H., & Chong, J. (2007). Beyond access: An analysis of the influence of the E-rate program in bridging the digital divide in American schools. *Journal of Information Technology Education, 6*, 387-406. Retrieved from Ebscohost Eric database.

Parr, J., & Ward, L. (2006). Building on foundations: Creating an online community. *Journal of Technology and Teacher Education, 14*(4), 775-793. Retrieved from Ebscohost Eric database.

Patten, B., Sanchez, I. A., & Tangney, B. (2006). Designing collaborative, constructionist and contextual applications for handheld devices [Electronic version]. *Computers and Education, 46*(3), 294-308.

Pearson, M., & Naylor, S. (2006). Changing contexts: Teacher professional development and ICT pedagogy [Electronic version]. *Education and Information Technologies, 11*(3), 283-291.

Pierce, R., & Stacey, K. (2008). Using pedagogical maps to show the opportunities afforded by CAS for improving the teaching of mathematics. *Australian Senior Mathematics Journal, 22*(1), 6-12. Retrieved from Ebscohost Eric database.

Ramaswami, R. (2008). Fill 'er up. *T.H.E. Journal, 35*(5), 32-38. Retrieved from http://www.thejournal.com/the/printarticle/?id=22571.

Ramos, A. J., Nangit, G., Ranga, A. I., & Trinona, J. (2007). ICT-enabled distance education in community development in the Philippines. *Distance Education, 28*(2), 213-229. Retrieved from Ebscohost Eric database.

Rau, P. P., Gao, Q., & Wu, L. (2008). Using mobile communication technology in high school education: Motivation, pressure, and learning performance [Electronic version]. *Computers & Education, 50*(1), 1-22.

Raza, A., Kausar, A. R., & Paul, D. (2007). The social democratization of knowledge: Some critical reflections on E-learning [Electronic version]. *Multicultural Education & Technology Journal, 1*(1), 64-74.

Reynolds, D. (2006). World class schools: Some methodological and substantive findings and implications of the international school effectiveness research project (ISERP). *Educational Research and Evaluation, 12*(6), 535-560. Retrieved from Ebscohost Eric database.

Rivero, V. (2006). High-speed broadband: A need for speed. *T.H.E. Journal, 33*(11), 30-35. Retrieved from http://thejournal.com/articles/18640.

Rumble, G., Koul, & B. N. (2007). *Open schooling for secondary & higher secondary education. costs and effectiveness in India and Namibia.* Commonwealth of Learning. Retrieved from http://www.col.org/SiteCollectionDocuments/Open_Schooling_Secondary_Higher_Education_071707.pdf.

Russell, M., O'Dwyer, L. M., Bebell, D., & Tao, W. (2007). How teachers' uses of technology vary by tenure and longevity. *Journal of Educational Computing Research, 37*(4), 393-417. Retrieved from Ebscohost Eric database.

Rye, S. A., & Zubaidah, I. (2008). Distance education and the complexity of accessing the internet. *Open Learning, 23*(2), 95-102. Retrieved from Ebscohost Eric database.

Sanchez, J., & Salinas, A. (2008). ICT & learning in Chilean schools: Lessons learned [Electronic version]. *Computers and Education. 51*(4), 1621-1633.

Sawtelle, S. (2008). Does this really work? The keys to implementing new technology while providing evidence that technology is successful. *Learning & Leading with Technology, 35*(8), 12-15. Retrieved from Ebscohost Eric database.

Sawyer, S., Hinnant, C. C., & Rizzuto, T. (2008). Pennsylvania's transition to enterprise computing as a study in strategic alignment [Electronic version]. *Government Information Quarterly, 25*(4), 645-668.

Schibeci, R., MacCallum, J., Cumming-Potvin, W., Durrant, C., Kissane, B., & Miller, E. (2008). Teachers' journeys towards critical use of ICT. *Learning, Media and Technology, 33*(4), 313-327. Retrieved from Ebscohost Eric database.

Selwyn, N. (2006). Exploring the "digital disconnect" between net-savvy students and their schools. *Learning, Media & Technology, 31*(1), 5-17. Retrieved from Ebscohost Eric database.

Serhan, D. (2007). School principals' attitudes towards the use of technology: United Arab Emirates technology workshop. *Turkish Online Journal of Educational Technology, 6*(2). Retrieved from http://eric.ed.gov.

Serim, F. (2007). The new gold rush: Establishing effective online learning policies. *Learning & Leading with Technology, 35*(2), 12-16. Retrieved from Ebscohost Eric database.

Shen, R., Wang, M., & Pan, X. (2008). Increasing interactivity in blended classrooms through a cutting-edge mobile learning system. *British Journal of Educational Technology, 39*(6), 1073-1086. Retrieved from Ebscohost Eric database.

Silla, V., & Hobbs, T. (2008). *Culturally accessible E-learning materials for international special educators.* Paper presented at Annual International Conference on Learning. Chicago, IL. Retrieved from http://eric.ed.gov.

Song, Y. (2007). Educational uses of handheld devices: What are the consequences [Electronic version]? *TechTrends: Linking Research and Practice to Improve Learning, 51*(5), 38-45.

Soule, H. (2008). Transforming school communities: Creating dialogue using web 2.0 tools. *Learning & Leading with Technology, 36*(1), 12-15. Retrieved from Ebscohost Eric database.

Spires, H. A., Lee, J. K., Turner, K. A., & Johnson, J. (2008). Having our say: Middle grade student perspectives on school, technologies, and academic engagement. *Journal of Research on Technology in Education, 40*(4), 497-515. Retrieved from Ebscohost Eric database.

St. Jean, M. (2008). Going on a desktop diet. *Learning & Leading with Technology, 36*(1), 22-27. Retrieved from Ebscohost Eric database.

Stevenson, O. (2008). Ubiquitous presence, partial use: The everyday interaction of children and their families with ICT. *Technology, Pedagogy and Education, 17*(2), 115-130. Retrieved from Ebscohost Eric database.

Subramony, D. P. (2007). Understanding the complex dimensions of the digital divide: Lessons learned in the Alaskan arctic. *Journal of Negro Education, 76*(1), 57. Retrieved from Ebscohost Eric database.

Suppanz, H. (2006). *Adapting the Icelandic education system to a changing environment.* Organisation for Economic Cooperation,and Development. Retrieved from http://eric.ed.gov.

Swan, K., Kratcoski, A., & van't Hooft, M. (2007). Highly mobile devices, pedagogical possibilities, and how teaching needs to be reconceptualized to realize them. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 10-12. Retrieved from Ebscohost Eric databse.

Teasdale, R. (2008). Outcome-led and process-led teaching. *Mathematics Teaching Incorporating Micromath,* (210), 3-7. Retrieved from Ebscohost Eric database.

Teo, T., Chai, C. S., Hung, D., & Lee, C. B. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education, 36*(2), 163-174. Retrieved from Ebscohost Eric database.

Tinker, R., Horwitz, P., Bannasch, S., Staudt, C., & Vincent, T. (2007). Teacher uses of highly mobile technologies: Probes and podcasts. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 16-21. Retrieved from Ebscohost Eric database.

Tompsett, C. (2007). Tipping into the abyss: With more than a virtual parachute? *ALT-J: Research in Learning Technology, 15*(2), 175-180. Retrieved from Ebscohost Eric database.

Tondeur, J., Valcke, M., & van Braak, J. (2008). A multidimensional approach to determinants of computer use in primary education: Teacher and school characteristics. *Journal of Computer Assisted Learning, 24*(6), 494-506. Retrieved from Ebscohost Eric database.

Tondeur, J., van Braak, J., & Valcke, M. (2007). Towards a typology of computer use in primary education. *Journal of Computer Assisted Learning, 23*(3), 197-206. Retrieved from Ebscohost Eric database.

Tondeur, J., van Braak, J., & Valcke, M. (2007). Curricula and the use of ICT in education: Two worlds apart? *British Journal of Educational Technology, 38*(6), 962-976. Retrieved from Ebscohost Eric database.

Twiner, A., Banyard, P., & Underwood, J. (2008). Transition between educational sectors and discontinuities of ICT resource and pedagogy. *Computers in the Schools, 24*, 139-152. Retrieved from Retrieved from Ebscohost Eric database.

Uibu, K., & Kikas, E. (2008). The roles of a primary school teacher in the information society. *Scandinavian Journal of Educational Research, 52*(5), 459-480. Retrieved from Ebscohost Eric database.

Uzunboylu, H. (2007). Teacher attitudes toward online education following an online inservice program. *International Journal on E-Learning, 6*(2), 267-277. Retrieved from Ebscohost Eric database.

Vahey, P., Roschelle, J., & Tatar, D. (2007). Using handhelds to link private cognition and public interaction. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 13-16. Retrieved from Ebscohost Eric database.

Valadez, J. R., & Duran, R. (2007). Redefining the digital divide: Beyond access to computers and the internet. *High School Journal, 90*(3), 31-44. Retrieved from Ebscohost Eric database.

Van 'T Hooft, M. (2008). Envisioning the future of education: Learning while mobile. *Learning & Leading with Technology, 35*(6), 12-16. Retrieved from Retrieved from Ebscohost Eric database.

VanFossen, P. J., & Waterson, R. A. (2008). "It is just easier to do what you did before...": An update on internet use in secondary social studies classrooms in Indiana. *Theory and Research in Social Education, 36*(2), 124-152. Retrieved from Ebscohost Eric database.

Varma, K., Husic, F., & Linn, M. C. (2008). Targeted support for using technology-enhanced science inquiry modules [Electronic version]. *Journal of Science Education and Technology*, *17*(4), 341-356.

Vekiri, I., & Chronaki, A. (2008). Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school [Electronic version]. *Computers & Education, 51*(3), 1392-1404.

Wagner, Daniel A., Bob Day, Tina James, Robert B. Kozma, Jonathan Miller and Tim Unwin. (2005). *Monitoring and evaluation of ICT in education projects: A handbook for developing countries*. Washington D.C.: International Bank for Reconstruction and Development/World Bank. Retrieved from http://www.infodev.org/en/Publication.9.html.

Wahlstedt, A., Pekkola, S., & Niemela, M. (2008). From E-learning space to E-learning place. *British Journal of Educational Technology, 39*(6), 1020-1030. Retrieved from Ebscohost Eric database.

Wang, Q. (2008). A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International, 45*(4), 411-419. Retrieved from Ebscohost Eric database.

Wang, Y., & Chen, V. D. (2007). Untangling the confounding perceptions regarding the stand alone IT course. *Journal of Educational Technology Systems, 35*(2), 133-150. Retrieved from Ebscohost Eric database.

Warschauer, M. (2006). Going one-to-one. *Educational Leadership, 63*(4), 34-38. Retrieved from Ebscohost Eric database.

Wasonga, T. A. (2007). Using technology to enhance collaborative learning [Electronic version]. *International Journal of Educational Management, 21*(7), 585-592.

Watson, D. (2006). Understanding the relationship between ICT and education means exploring innovation and change [Electronic version]. *Education and Information Technologies, 11*(3), 199-216.

Weller, A. M., Bickar, J. C., & McGuinness, P. (2008). Making field trips podtastic!: Use of handheld wireless technology alleviates isolation and encourages collaboration. *Learning & Leading with Technology, 35*(6), 18-21. Retrieved from Ebscohost Eric database.

Whittier, D., & Lara, S. (2006). Preparing tomorrow's teachers to use technology (PT3) at Boston university through faculty development: Assessment of three years of the project. *Technology, Pedagogy and Education, 15*(3), 321-335. Retrieved from Ebscohost Eric database.

Wijekumar, K. J., Meyer, B. J. F., Wagoner, D., & Ferguson, L. (2006). Technology affordances: The "real story" in research with K-12 and undergraduate learners. *British Journal of Educational Technology, 37*(2), 191-209. Retrieved from Ebscohost Eric database.

Williams, L. A., Atkinson, L. C., Cate, J. M., & O'Hair, M. J. (2008). Mutual support between learning community development and technology integration: Impact on school practices and student achievement. *Theory into Practice, 47*(4), 294-302. Retrieved from Ebscohost Eric database.

Wishart, J. (2008). Challenges faced by modern foreign language teacher trainees in using handheld pocket PCs (personal digital assistants) to support their teaching and learning [Electronic resource]. *Recall, 20*(3), 348-360.

Wong, E. M. L., & Li, S. C. (2008). Framing ICT implementation in a context of educational change: A multilevel analysis. *School Effectiveness and School Improvement, 19*(1), 99-120. Retrieved from Ebscohost Eric database.

Wong, E. M. L., Li, S. S. C., Choi, T., & Lee, T. (2008). Insights into innovative classroom practices with ICT: Identifying the impetus for change. *Educational Technology & Society, 11*(1), 248-265. Retrieved from http://www.ifets.info/journals/11_1/18.pdf.

Wong, K. (2007). Implementation of ICT in primary schools in Hong Kong: Consistency and discrepancy of attitudes between school heads and teachers. *International Educational Technology (IETC) Conference*, Nicosia, Turkish Republic of Northern Cyprus. Retrieved from http://eric.ed.gov.

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and Teacher Education, 14*(1), 173-207. Retrieved from Ebscohost Eric database.

Wu, W., Chang, H., & Guo, C. (2008). An empirical assessment of science teachers' intentions toward technology integration. *Journal of Computers in Mathematics and Science Teaching, 27*(4), 499-520. Retrieved from Ebscohost Eric database.

Xuereb, K. (2006). A comparative study of information and communications technology policy in primary education in two small islands. *Technology, Pedagogy and Education, 15*(1), 31-45. Retrieved from Ebscohost Eric database.

Yang, Y. C., & Chan, C. (2008). Comprehensive evaluation criteria for English learning websites using expert validity surveys [Electronic version]. *Computers & Education, 51*(1), 403-422.

Yarnall, L., Carriere, S., Stanford, T., Manning, C., & Melton, B. (2007). What happens to "writing across the curriculum" with handheld devices? *Educational Technology Magazine: The Magazine for Managers of Change in Education, 47*(3), 26-29. Retrieved from Ebscohost Eric database.

Yashima, T., & Zenuk-Nishide, L. (2008). The impact of learning contexts on proficiency, attitudes, and L2 communication: Creating an imagined international community [Electronic version]. *System: An International Journal of Educational Technology and Applied Linguistics, 36*(4), 566-585.

Younie, S. (2006). Implementing government policy on ICT in education: Lessons learnt [Electronic version]. *Education and Information Technologies, 11*(3), 385-400.

Yuen, A. H. K., & Ma, W. W. K. (2008). Exploring teacher acceptance of E-learning technology. *Asia-Pacific Journal of Teacher Education, 36*(3), 229-243. Retrieved from Ebscohost Eric database.

Zevenbergen, R., & Logan, H. (2008). Computer use by preschool children: Rethinking practice as digital natives come to preschool. *Australian Journal of Early Childhood, 33*(1), 37-44. Retrieved from http://www.earlychildhoodaustralia.org.au/index2.php?option=com_content&do_pdf=1&id=1034.

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

Zucker, A. A., Tinker, R., Staudt, C., Mansfield, A., & Metcalf, S. (2008). Learning science in grades 3-8 using probeware and computers: Findings from the TEEMSS II project [Electronic version]. *Journal of Science Education and Technology, 17*(1), 42-48.

Appendix A: Meta-Review Search Terminology Used in GeSci Study

I. Educational Management and ICTs
   a. Cost Effectiveness
   b. Leadership Effectiveness
   c. Instructional Leadership
   d. Technology Integration
   e. Change Strategies
   f. Educational Change
   g. Educational Development
   h. Information Policy
   i. Policy Analysis
   j. Program Effectiveness
   k. Program Evaluation
   l. Program Validation
   m. School Effectiveness
   n. State Standards

II. ICT Infrastructure
   a. Access to Computers
   b. Equal Access
   c. Computer-mediated Communication
   d. Telecommunications
   e. Rural Areas
   f. Rural Education
   g. Distance Education
   h. Web-based Instruction
   i. Online courses
   j. Handheld Devices
   k. Computer Networks
   l. Client-Server Architecture

III. Integration of ICTs into Teaching and Learning
   a. Instructional Innovation
   b. Games
   c. Social Networks (Teacher Education)
   d. Computer Simulation
   e. Technology Integration (Effect on Teaching and Learning)
   f. Gender Differences
   g. Gender Issues
   h. Constructivism
   i. Problem Solving
   j. Learning Strategies
   k. Instructional Effectiveness
   l. Handheld Devices (ICT Infrastructure)
   m. Field Trips

IV. Teacher Education and ICTs
    a. Preservice Teacher Education
    b. Preservice Teachers
    c. Field Experience Program
    d. Student Teachers
    e. Mentors
    f. Beginning Teacher Induction
    g. Discussion Groups
    h. Educational Environment
V. Educational content and ICTs
    a. Citizenship Responsibility
    b. Science Activities
    c. Language Acquisition
    d. Mathematics Instruction
VI. General Terms
    a. Research Needs
    b. Educational Trends
    c. Teacher Attitudes
    d. Developing Nations
    e. Distance Education