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## School technology leadership: Lessons from empirical research

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While research has found that technology leadership is an important factor for effective integration of technology in schools, there is a paucity of research on technology leadership in schools. This paper reviewed 12 empirical reports on technology leadership and a grounded theory approach was used to derive the key findings. Several roles of technology leaders were identified, which are categorized into four main areas of change: infrastructure, organization structure and policy, pedagogy and learning, and school culture. The corresponding competencies of school technology leaders were identified. Several relationships were established between technology leadership and other factors: School technology leadership is a strong predictor on the level of technology use in schools; the cultural and structural characteristics of schools could affect the level of computer use in classrooms; transformational leadership is correlated with a principal's ICT competencies. Researchers have also started to explore the views of followers and the recursive relationships between the leader and the followers. Based on the review, recommendations for future research are discussed.

Keywords: school technology leadership, review, empirical research

### Introduction

We are living in a time that has been characterized as the Digital Age and the Knowledge Age. The rapid advancement in information and communication technologies (ICT), coupled with the demand of the knowledge society, has a huge impact on education. For example, in the past decade, ICT is becoming commonplace in many K-12 schools. Competitive economies like Finland, Hong Kong, Singapore, the United Kingdom, and the United States have been implementing nation-wide policies on the use of ICT in education; in fact, many of them are into their second or third nation-wide ICT master plans. Educational researchers are also devoting much effort to studying factors affecting technology integration in schools (Lawson & Comber, 1999; Mumtaz, 2000), of which school leadership has been identified as one of the most important factors (Byrom & Bingham, 2001).

While position papers that represent opinions of authors are abound, empirical research on school leadership for technology integration is only slowly gaining momentum (Michael, 1998). Even though most of the position papers contain good ideas (e.g., what a technology leader could do), the warrants for the claims made in these papers are usually not explicitly declared. Some of these claims apparently were based on personal experience or secondary sources. This paper aims to address this gap by focusing on the findings from empirical studies on leadership for technology integration in schools. Specifically, this review is guided by the following questions:

1. What are the roles of school technology leadership?
2. What are the relationships among constructs related to school technology leadership?

The first question may look deceptively simple but many studies have simply identified a list of what technology leaders do or should do. While there are values in looking into specific details, this review aims to categorize these roles into a few key areas of change a leader could enact. This parsimonious classification could provide us a clearer overview of the relationships among constructs related to school technology leadership, which is the focus of the second research question. While the study focuses on technology leadership in K-12 schools, many of the generic issues related to technology integration will resonate with leaders in institutes of higher education. Knowing what happens in K-12 schools will also benefit technology leaders in higher education in terms of managing students' expectations and leveraging students' entering ICT competencies to achieve higher level goals.

Different terms have been used in various papers, including *ICT leadership* (Yee, 2000), *IT leadership* (Hollingworth & Mrazek, 2004), *e-leadership* (Gurr, 2004) or *educational technology leadership* (Kearsley & Lynch, 1994). In this paper, the term school technology leadership (Anderson & Dexter, 2000, 2005) is used because this paper focuses on review of studies conducted in K-12 schools. The term *technology* is preferred over *ICT* or *IT* to indicate a more inclusive scope of use of technologies.

## Method

This paper focuses on a review of research, which aims to advance the collective understanding of research in a field. As Shulman (1999) argued, one of the hallmarks of good scholarship is *generativity*, or the ability to build on the existing scholarship and findings from other researchers. This is particularly important in educational research where the diversity of audience and social contexts presents a challenge to establishing shared research problems and methodologies. This study consults the standards for a literature review suggested by Boote and Beile (2005).

There were three main phases in this review: identification of relevant literature, identification of key ideas in each paper, and synthesis of frameworks for educational technology leadership. In the first phase, I first searched for peer-reviewed journals in five electronic databases, which include Academic Search Premier, ERIC, Educational Research Complete, PsychARTICLES and PsyINFO. Using the keywords "Education and Technology and Leadership", 255 articles were found. A review of the abstracts led to 9 empirical studies relevant to K-12 schools. This is followed by an expansive snowballing method of tracing relevant references that were cited in these 9 articles and a further search in two journals: *Technology, Pedagogy and Education*; and *Educational Administration Quarterly*. This yielded 14 empirical research reports, of which two were discarded as they focused on the perception of a single person. Ultimately, 12 empirical reports were selected for this review. Appendix 1 summarizes these 12 reports.

The key themes from the findings of the empirical reports were generated by using a grounded theory approach, in particular, the constant comparison method. The papers were first scanned for their research foci, which resulted in two categories: Identification of roles and competencies of technology leaders, and Relationship among leadership factors. The roles of leaders were further regrouped into four categories and a draft concept map was generated. Next the independent and dependent variables in quantitative reports were identified and integrated into the concept map. Relationships depicted or implied in qualitative reports were then incorporated. Consequently, a concept map was developed to summarize the key findings.

## Findings

A summary of the findings from the empirical reports on school technology leadership is presented in the concept map (see Figure 1). Because the studies are conducted with different types of participant in various contexts, this map is at best a summary of findings; the relationships depicted in this map do not represent generalized principles. This map aims to capture concisely the key findings from the review and acts as an advanced organizer for the discussion. Details on the roles of technology leaders and relationships among various constructs will be presented in the discussion that follows.

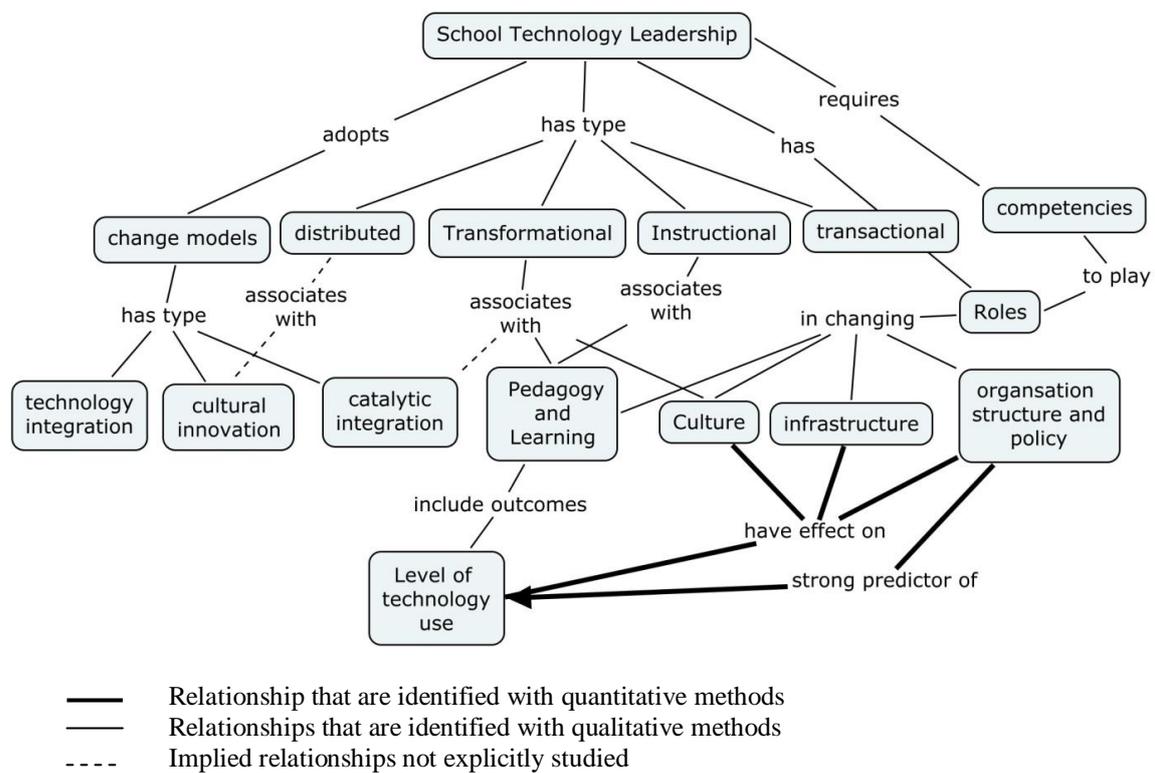
### The roles of school technology leaders

One of the main foci of the research papers is to examine the functional roles of technology leadership, in other words, what technology leaders do or should do. For example, Yee (2000) conducted an in-

depth case study of seven schools in Canada, New Zealand and the United States. Using the lens of transformational leadership, she identified eight roles of school technology leaders: equitable provision of hardware and resources, learning-focused envisioning, adventurous learning (experimenting) with technologies, patient teaching (coaching) of teachers and students, protective enabling of teachers and students with shared leadership, constant monitoring of school progress, entrepreneurial networking with partners and stakeholders, and careful challenging of staff to be innovative. Similarly, Schiller (2002) interviewed principals from 12 Australian elementary schools that were effective in ICT implementation to identify the roles of ICT leadership. I have categorized these functional roles into four areas of change that technology leaders can enact (see Table 1): Infrastructural change, organizational and policy change, pedagogical and learning change and cultural change. There is an increasing level of complexity and difficulty in achieving these changes.

*Infrastructural change*

School leaders play an important role in providing an infrastructure that is conducive to the use of educational technologies. Technology infrastructure includes hardware, software, and resources. Hardware refers to physical structure and equipment like computer networks, computers, projectors, and printers; software refers to computer programs that can be used as generic tools to facilitate administration or learning, for example, learning management systems, spreadsheet or database; and resources which contain information that could facilitate learning, for example, a tutorial program or an online encyclopedia. It is important that the provision of infrastructure is equitable to all staff and students, rather than to a selected group of people (Yee, 2000).



**Figure 1: Summary of relationships among types of school technology leadership and their impact**

*Organizational and policy change*

Organizational and policy change is perhaps one of the most common actions taken by school leaders. Anderson and Dexter (2000, 2005) identified several indicators for technology leadership that include setting up of a technology committee, district support for schools, staff development policy, school technology budget and intellectual property policy. Other organizational change could include the appointment of different levels of technology leaders, setting up of technology support services, and staff appraisal policy.

### *Pedagogical and learning change*

Learning outcomes of students have been a main point of debate between advocates and opponents of educational technology. Technology leaders in schools acknowledge their roles in enhancing student learning outcomes and pedagogical quality through the use of technologies (Schiller, 2002; Yee, 2000). For example, “learning-focused envisioning” and “adventurous learning” were identified as important roles of school leaders (Yee, 2000, pp. 293-294). School leaders indicated that student learning should be the main focus for decision making related to ICT policies in schools and teachers should be encouraged to experiment (adventurous learning) with the use of technologies in instruction (Yee). Using hierarchical linear modeling, Marks and Printy (2003) found that only when transformational leadership is integrated with instructional leadership, there is substantial impact on pedagogical quality of teaching and student achievement. In other words, while leaders can build organization capacity through transformation leadership, only when instructional leadership is displayed by the leaders, the individual competence of teachers and students can be enhanced.

### *Cultural change*

Cultural characteristics of a school refer to “the way people perceive, think and feel about things in schools” (Tondeur, Devos, Van Houtte, van Braak & Valcke, 2009, p. 226) or “the basic assumptions, norms and values and cultural artifacts that are shared by school members, which influence their functioning at school” (Maslowski, 2001, 8-9). Cultural change is elusive for the difficulty in operationalizing the construct for measurement, but it is perhaps one of the most difficult but effective ways to achieve high quality and sustained integration of technology into classrooms (Yuen, Law, & 2003).

### *Competencies of technology leaders*

Given the multiple roles of technology leaders, some researchers began to examine the necessary competencies of technology leaders. A leadership committee in Alberta was set up to analyze the competencies of technology leaders and conduct a needs assessment for their professional development. Hollingsworth and Mrazek (2004) surveyed 512 technology leaders at both district and school level. Eight major knowledge, skill and attribute areas were identified as important for district IT leaders: leadership and visioning; learning and teaching; productivity and professional practice; support, management and operations; assessment and evaluation; knowledge of problem solving and information technologies; social, legal, and ethical issues; organizational relations and communications. School level technology leaders share a similar list of knowledge, skill and attribute areas except for knowledge of problem solving and information technologies and organizational relations and communications. Chang (2003) surveyed 500 teachers and staff from 27 US schools on their perception of technology leaders. Using structural equation modeling, Chang identified four dimensions of technology leadership competencies: vision, planning, and management; staff development and training; technology and infrastructure support; evaluation, research and assessment of staff. In addition, a good technology leader must possess good interpersonal and communication skills.

**Table 1: Summary of findings in empirical reports categorized into four areas of change**

Areas of change	What it entails	Operational indicators	Competencies
Infrastructure	<ul style="list-style-type: none"> <li>• Equitable provision of hardware and resources (Yee, 2000)</li> <li>• Ensure availability of hardware and software (Schiller, 2002)</li> </ul>	Structural school characteristics (Tondeur et al., 2009) <ul style="list-style-type: none"> <li>• ICT infrastructure</li> </ul> Infrastructure (Anderson & Dexter, 2000, 2005) <ul style="list-style-type: none"> <li>• High speed internet access</li> <li>• Student/computer ratio</li> <li>• Hardware expenditure</li> <li>• Software expenditure</li> </ul>	<ul style="list-style-type: none"> <li>• Support, management and operations (Hollingsworth et al., 2004)</li> <li>• Technology and infrastructure support (Chang, 2003)</li> <li>• Knowledge of problem solving and IT (Hollingsworth et al., 2004)</li> </ul>
Organization structural and policy	<ul style="list-style-type: none"> <li>• Constant monitoring of school progress (Schiller, 2002; Yee, 2000)</li> <li>• Entrepreneurial networking with partners and stakeholders (Yee, 2000)</li> </ul>	Structural school characteristics (Tondeur et al., 2009) <ul style="list-style-type: none"> <li>• ICT planning</li> <li>• ICT support</li> </ul> Technology leadership (Anderson & Dexter, 2000, 2005)	<ul style="list-style-type: none"> <li>• Assessment and evaluation of progress (Hollingsworth et al., 2004)</li> <li>• Evaluation, research and assessment (Chang, 2003)</li> </ul>

	<ul style="list-style-type: none"> <li>• Apply pressure and provide support (Schiller, 2002)</li> <li>• Provide assistance to staff (Schiller, 2002)</li> <li>• Personal involvement in decision making (Schiller, 2002)</li> <li>• Engage change facilitator (Schiller, 2002)</li> <li>• Set clear goals and targets (Yuen et al., 2003)</li> </ul>	<ul style="list-style-type: none"> <li>• Presence of a technology committee</li> <li>• Technology planning, maintenance or administration</li> <li>• Staff development policy</li> <li>• Technology budget</li> <li>• District support for technology costs in the school</li> <li>• Special grant for IT experimental program</li> <li>• Intellectual property policy</li> <li>• Principal use of email</li> </ul>	<ul style="list-style-type: none"> <li>• Social, legal and ethical issues (Hollingsworth et al., 2004)</li> <li>• Organization relations and communications (Hollingsworth et al., 2004)</li> </ul>
Pedagogy and Learning	<ul style="list-style-type: none"> <li>• Learning-focused vision (Yee, 2000)</li> <li>• Adventurous learning with technology (Yee, 2000)</li> <li>• Patient teaching of teachers and students (Yee, 2000)</li> <li>• Modeling or coaching of staff (Schiller, 2002)</li> <li>• Provide staff development (Schiller, 2002)</li> </ul>	<p>Technology outcomes (Anderson &amp; Dexter, 2000, 2005)</p> <ul style="list-style-type: none"> <li>• Use of Internet and email</li> <li>• Technology integration</li> <li>• Student use of tools</li> </ul>	<ul style="list-style-type: none"> <li>• Learning and teaching (Hollingsworth et al., 2004)</li> <li>• Productivity and professional practice (Hollingsworth et al., 2004)</li> <li>• Staff development and training (Chang, 2003)</li> <li>• Computer competence (Afshari, 2009)</li> </ul>
Culture	<ul style="list-style-type: none"> <li>• Protective enabling of teachers and students with shared leadership (Yee, 2000)</li> <li>• Careful challenging of staff to be innovative (Yee, 2000)</li> <li>• Distributed or shared leadership (Dexter, 2007; Yuen et al., 2003)</li> </ul>	<p>Cultural school characteristics (Tondeur et al., 2009)</p> <ul style="list-style-type: none"> <li>• Innovativeness</li> <li>• Goal orientedness</li> <li>• Supportive leadership</li> </ul> <p>Transformative leadership (Ng, 2008)</p> <ul style="list-style-type: none"> <li>• Identifying and articulating a vision</li> <li>• Fostering acceptance of group goals</li> <li>• Providing individualized support</li> <li>• Offering intellectual stimulation</li> <li>• Providing an appropriate model</li> <li>• Creating high performance expectations</li> <li>• Strengthening school culture</li> <li>• Building collaborative structure</li> </ul>	<ul style="list-style-type: none"> <li>• Leadership and visioning (Hollingsworth et al., 2004)</li> <li>• Vision, planning and management (Chang, 2003)</li> <li>• Interpersonal communication (Chang, 2003)</li> </ul>

### Relationships among constructs related to school technology leadership

In the above section, four categories of areas of change that a school technology leader could enact were identified. Next, the relationships between the leadership types and their corresponding impacts are examined.

School technology leadership is a strong predictor of the level of technology use in schools. Anderson and Dexter (2000, 2005) conducted a nation-wide survey study with 1,150 U.S. schools involving 867 school principals, 4100 teachers and 800 ICT coordinators. Indicators for organization structure and policy (e.g., presence of technology committee) were used for the independent variable *technology leadership*, and indicators for hardware (e.g., computer density and internet bandwidth) were used for the independent variable *infrastructure*. They found that technology leadership was a stronger predictor compared to infrastructure factors for three different dependent measures on technology outcomes: frequency of use of Internet by students and teachers, frequency of integration of ICT into lessons, and extent to which students use ICT for academic works in the school. They proposed that technology

leadership (1) has direct impact on technology outcomes in schools, and (2) plays a mediating role between infrastructural factors and technology outcomes.

The cultural and structural characteristics of schools could affect the level of computer use in classrooms. Tondeur, Devos, Van Houtte, van Braak and Valcke (2009) investigated 68 primary schools in Belgium and categorized them into two clusters based on cultural and structural characteristics of schools. Tondeur et al. (2009) operationalized the *cultural* construct by measuring the staff's attitudes towards innovation (innovativeness), the extent to which school vision is defined and shared by school members (goal orientedness) and the extent to which the principal exhibits supportive leadership. The structural characteristics include organizational features like ICT support and ICT planning as well as infrastructural characteristics. Similar to the study by Anderson and Dexter (2000, 2005), the dependent variable (level of technology use) is operationalized as frequency of use of the computer in classrooms, including specific purposes like presentations, doing assignments or collaborative learning. It was found that schools (N=41) which are strong in cultural characteristics and structural characteristics (ICT planning, support and infrastructure) have a significant higher mean level of computer use in classroom compared with schools (N=27) that are weak in these two measures.

In at least five studies, generic types (or styles) of leadership form the theoretical basis or lens of interpretation. These leadership types include: transformational leadership, instructional leadership, transactional leadership and distributed leadership. Transformational leadership (Bass, 1985; Burns, 1978; Leithwood, 1994) focuses on building cultural identity, engaging the followers in a commitment to innovate in response to changes in the environment. Transactional leadership (Lee, 2005) focuses on economic exchange (e.g., rewards and punishment) to engage the followers in achieving the goals. Instructional leadership (Murphy, 1998) focuses on roles related to teaching and learning. Rather than focusing on individuals, distributed leadership (Spillane, 2005) views leadership as distributed among various leaders at different levels within an organization, and studies the reciprocal interactions among the leaders and the followers.

The relationships between types (or styles) of leadership and other factors were the focus in several papers. Ng (2008) developed and validated an instrument based on characteristics of transformational leadership (Leithwood, 1994) with 80 secondary school teachers from Singapore schools. The respondents generally agreed that the eight dimensions of transformational leadership could influence integration of ICT into teaching. These eight dimensions include: identifying and articulating a vision, fostering acceptance of group goals, providing individualized support, offering intellectual stimulation, providing an appropriate model, creating high performance expectations, and strengthening school culture. Afshari, Bakar, Luan, Samah, and Fooi (2009) administered survey to 30 secondary school principals in Tehran. They found significant correlation between the principal's computer competency level and transformational leadership practices but no such relationship was found with transactional leadership practices. They further suggested that transformational leadership could help to improve the use of technology for teaching and learning.

Schools adopt different change models in their ICT implementation. Yuen, Law, and Wong (2003) conducted case study of 18 schools in Hong Kong. They identified three change models, based on three criteria: perceived roles and impact of ICT, vision and values of ICT, and culture and history of change in the school. Technology adoption model focuses on enhancing ICT competency of students; it is associated with top-down leadership that sets clear goals and guidelines. Catalytic integration model focuses on the use of ICT for curriculum reform; it is associated with visionary leadership that is also top-down. Cultural innovation model focuses on empowering staff and students to create new ideas with ICT; it is associated with distributed leadership.

In most studies, the top leaders (e.g., the school principals) were assumed to be endowed with institutional power of technology leadership. This assumption is being challenged by researchers adopting the theoretical lens of distributed leadership. For example, Dexter (2007) studied four U.S. schools and found that technology leadership is a school characteristic (rather than individual) and it is distributed across people who have formal authority of decision making. Ultimately, technology implementation in classrooms is dependent on teachers. Teachers identified technology leaders as those who have formal authority (assigned titles like ICT coordinator) and have personal interactions with. Thus, there is a "recursive effect among the leaders, the situation, and the followers" (Dexter, 2007, p.20). This recursive effect is illustrated in a study by Lai and Pratt (2004). In this study, 21 ICT coordinators in New Zealand schools were interviewed. The coordinators reflected that school leaders

could impede the works of the coordinator by not providing sufficient time for planning, not providing professional development and not giving recognition to the coordinators.

## Discussion

Research studies have uncovered a range of factors that could affect technology integration in schools (e.g., Mumtaz, 2000) and technology leadership has been identified as one of the most critical factors (e.g., Byrom & Bingham, 2001; Pelgrum & Law, 2003). This review, however, shows the paucity of empirical studies in the field of school technology leadership. Among the shortlisted empirical studies, only three attempted to study quantitatively the relationships among the constructs. On the other hand, there are many position papers and books on technology leadership (e.g., Bennett, 2008; Schoeny, 2002) that suggest ideas on technology leadership. The prominence of ideational papers and qualitative studies indicate the infancy of this field of study, which is a potentially fertile area for research.

First, the selected studies were conducted in different countries (e.g., U.S., Canada, Singapore, Belgium, and Tehran) and contexts (elementary schools to high schools). Leadership is likely to be influenced by contextual factors, for example, the power relationship between the leader and the followers and the institutional authority assumed by the school leaders might be different in different contexts. Consequently, the relationships established in one context might not be applicable to another context. Replicating similar studies in different contexts or comparison studies across contexts could help to reveal the effects of the contextual factors. For example, would the 8-dimension transformational leadership established by Ng (2008) in Singapore be applicable in another country or context? If not, what could contribute to the differences?

Second, in many survey studies, the target respondent groups are different. For example, Schiller (2002) solicited the views of school principals whereas Yee (2000) collected information from different stakeholders in the schools. In cases where multiple sources of data were collected, the researchers tend to present the triangulated findings. Some studies (e.g., Dexter, 2007; Lai & Pratt, 2004) have shown that middle level leaders or the followers have their unique needs and possess alternative interpretations of leadership. It would be valuable to examine perspectives of different stakeholders within the same site of studies. It might reveal the discrepancies between espoused leadership (by the leader), the enacted leadership (by an observer) and the perceived leadership (by the followers). The notion of distributed leadership (see Dexter, 2007) has also challenged the common assumption that the school principal is the technology leader. It is valuable to question the assumption that the leader will affect the followers. The recursive relationship between the leaders and followers is an important area to explore. For example, in Yee's (2000) study, data were collected from the principals, staff and students, but the consolidated interpretations of the key roles of principals were presented using triangulation of data. Analyzing the same set of data but focusing on differences in views among the stakeholders might reveal unexpected findings.

Third, many studies are clearly influenced by theories and concepts of generic educational leaderships, for example, transformational leadership. While there are studies (e.g., Ng, 2008) that validate the applicability of these theories for technology leadership, it will be valuable to examine whether technology leadership possesses unique features or is more prominent in some dimensions of the leadership style. In addition, these different leadership types (or styles) need not be mutually exclusive. For example, Marks and Printy (2003) studied the impact of integrated leadership, which comprised both transformational leadership and instructional leadership.

Fourth, there remain many relationships among the leadership constructs that can be explored, for example, the relationship between leadership type and change process. Each of the areas of change can be explored further, for example, quality of pedagogy and student achievement can be dependent variables and their relationships with leadership styles or change process can be examined. Taking the view of distributed leadership, we will need to expand the unit of analysis from a person (leader), to a group (e.g., a school). It will be valuable to study the complex relationship among various stakeholders in an organization. For example, Spillane, Halverson and Diamond (2001) proposed the use of an activity system to study distributed leadership. Marks and Printy (2003) used hierarchical linear modeling to study different levels of impact of the technology leaders on the teachers and on the students.

The above discussion also highlights some methodological considerations for researchers, which could affect both quantitative and qualitative research. For example, the target respondents/participants would be different depending on whose perspective is sought, the leader, the follower, or both. The unit of analysis will be different depending on whether the focus is on a person or an organization. Consequently, the analyses could focus on unidirectional impact from the leader or reciprocal relationship between the leader and the followers. The assumption on the order of impact (first order, second order) could affect the type of statistical analysis or qualitative interpretation of field observation.

Even though this study focuses on the review of K-12 school technology leadership, most of the findings and implications discussed in this paper could be useful to institutes of higher education. For example, to examine technology leadership from multiple perspectives of various stakeholders, to validate the applications of generic educational leadership, and to explore relationships among various leadership constructs. These issues are likely to be generic for different levels and types of education institutions. In addition, knowing what the students experience in K-12 schools will benefit technology leaders in institutes of higher education. For example, they could leverage the entering technology competencies of the students to achieve higher level educational goals; they could also manage the expectations of the students in terms of types and extent of applications of educational technologies. The differences between technology leadership in K-12 schools and higher education are likely to be contributed by issues like funding, size of student population, size and types of physical infrastructure, nature of learners, and nature of curriculum content. A meta-comparison of technology leadership between K-12 schools and higher education could be conducted when there are sufficient empirical studies carried out in each field of study.

## Conclusion

This paper sets out to review empirical studies on school technology leadership. Two broad categories of studies were found: studies that focused on identification of roles and competencies of technology leaders and studies that explored the relationships between various leadership factors. The roles of technology leaders were categorized into four main areas of change: infrastructure, organization structure and policy, pedagogy and learning, and school culture. Most of the studies (9 out of 12) were underpinned by generic leadership theory: transformational leadership, instructional leadership, transactional leadership and distributed leadership. Several relationships were established between technology leadership and other factors: School technology leadership is a strong predictor of the level of technology use in schools; the cultural and structural characteristics of schools could affect the level of computer use in classrooms; transformational leadership is correlated with principal's ICT competencies. At least two studies examined the views of the middle level leader and explored the reciprocal relationships between the leader and the followers.

This review aims to facilitate future research on school technology leadership, which is a critical factor that could affect quality of technology integration in schools, but yet an under-explored field of study. Possible research areas related to technology leadership are suggested: the influence of contextual factors on leadership, technology leadership as viewed from perspectives of different stakeholders, relationships among various leadership factors. The review also uncovers several important methodological considerations, for example, the unit of analysis, the choice of respondents or participants, and assumptions on the order of impact.

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## Appendix 1

### Selected empirical studies and key findings

Selected empirical reports	Key findings relevant to this review	Method
Afshari, M., Bakar, K. A., Wong, S.L., Smah, B.A., Foo, S.F. (2009). <i>Technology and school leadership, Technology, pedagogy and education, 18(2), 235-248.</i>	Significant correlation between computer use and transformational leadership, and between computer use and computer competence	Survey of principals from 30 Tehran secondary schools
Anderson, Ronald E., & Dexter, Sara L. (2000). School technology leadership: Incidence and impact. UC Irvine: Center for Research on information Technology and Organizations.	Technology leadership is a stronger predictor on technology outcomes than infrastructure and expenditure.	Survey of principals, technology coordinators and teachers from 800 schools in U.S.
Anderson, R., & Dexter, S. (2005). School technology leadership: An empirical investigation of prevalence and effect. <i>Educational Administration Quarterly, 41(1), 49-82.</i>	Technology leadership is a stronger predictor on technology outcomes than infrastructure and expenditure.	Survey of principals, technology coordinators and teachers from 800 schools in U.S.
Chang, I. (2003). Assessing the dimensions of principals' effective technology leadership: An application of structural equation modelling. <i>Educational Policy Forum, 6(1), 111-141.</i>	Four dimensions of effective technology leadership validated using structural equation modelling: Vision, planning, and management; Staff development and training; Technology and infrastructure support; Evaluation, research, and assessment. Interpersonal communication is an important factor on technology leadership.	Survey of 500 teachers and staff from 27 schools in Midwest U.S.
Dexter, S. (April, 2007). Show me the leadership: The impact of distributed technology leadership teams' membership and practices at four laptop schools. Paper presented at the 88th Annual Meeting of the American Educational Research Association, Chicago, IL.	A study of distributed leadership. Teachers identify members with specific titles and roles and who interacted with them directly as the leader.	Case studies of 4 middle Laptop schools in U.S. Involved interview of students, teachers and administrators; classroom observation.
Hollingsworth, M., & Mrazek, R. (2004). Information technology leadership in education: An Alberta needs assessment. Edmonton, Alberta: Learning and Technology Research, Stakeholder Technology Branch. Retrieved 17 June 2010 from <a href="http://www.uleth.ca/edu/faculty/members/mraz.pgs/cv/public.cfm#pub3">http://www.uleth.ca/edu/faculty/members/mraz.pgs/cv/public.cfm#pub3</a> .	Competencies and needs assessment of technology leaders at district and school level: Leadership and visioning; Learning and teaching; Productivity and professional practice; Support, management and operations; Assessment and evaluation; Knowledge of problem solving and information technologies; Social, legal and ethical issues; Organizational relations and communications.	Survey of superintendent and school principals in 63 school districts in Alberta. More than 400 respondents.
Lai, K. W., & Pratt, K. (2004). Information and communication technology (ICT) in secondary schools: the role of the computer coordinator. <i>British Journal of Educational Technology, 35(4), 461-475.</i>	Roles of ICT coordinators: Envisioning and planning; Budgetary and resource allocation; Technical and curriculum support. Obstacles faced by the coordinators: Time for planning, need for professional development, recognition from top school leaders.	Survey of ICT coordinators from 22 secondary schools in New Zealand, of which 14 were interviewed.
Selected empirical reports	Key findings relevant to this review	Method
NG, W. (2008). Transformational leadership and the integration of	Validated 8 dimensions of transformation leadership for ICT integration: Identifying	Survey of 80 teachers from secondary schools

information and communications technology into teaching. <i>The Asia-Pacific Education Researcher</i> , 17(1), 1-14.	and articulating a vision; Fostering acceptance of group goals; Providing individualized support; Offering intellectual stimulation; Providing an appropriate model; Creating high performance expectations; Strengthening school culture; Building collaborative structure.	in Singapore.
Schiller, J. (2002). Interventions by school leaders in effective implementation of information and communications technology: Perceptions of Australian principals. <i>Technology, Pedagogy and Education</i> , 11(3), 289-301.	8 roles of principals as ICT leaders: support, provision of assistance, modelling, coaching, monitoring, collaboration, and visioning.	Semi-structured interview of 12 elementary schools in Australia.
Tondeur, J., Devos, G., Van Houtte, M., Van Braak, J., & Valcke, M. (2009). Understanding structural and cultural school characteristics in relation to educational change: the case of ICT integration. <i>Educational Studies</i> , 35(2), 223-235.	Structural and cultural characteristics of schools are strongly correlated. 68 primary schools were grouped into 2 clusters of schools based on these characteristics. Cluster with strong structural and cultural characteristics has significantly better ICT integration in classroom.	Survey of 527 teachers from 68 Belgium primary schools.
Yee, D. L. (2000). Images of school principals' information and communications technology leadership. <i>Technology, Pedagogy and Education</i> , 9(3), 287-302.	8 roles of principals as ICT leaders: Equitable provision of hardware and resources, learning-focused envisioning, adventurous learning with technologies, patient teaching of teachers and students, protective enabling of teachers and students with shared leadership, constant monitoring of school progress, entrepreneurial networking with partners and stakeholders, and careful challenging of staff to be innovative	Case studies of 10 ICT-enriched schools in Canada, New Zealand, and the U.S.
Yuen, A., Law, N., & Wong, K. (2003). ICT implementation and school leadership. <i>Journal of Educational Administration</i> , 41(2), 158-170.	3 models of ICT leadership and change process: technology adoption, catalytic integration and cultural innovation. Implies impact on teaching and learning processes	Case study of 18 schools in Hong Kong

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