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ERRATUM

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The second and third authors of this article were inadvertently omitted in the original publication. The correct author group appears in this erratum.

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School Leadership in ICT Implementation: Perspectives from Singapore

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Abstract Singapore has implemented two Masterplans for Information Communication Technology (ICT) in education over the last decade. This article examines Singapore teachers' perspectives of how leadership for ICT implementation in schools is distributed among leaders, by means of a survey conducted in 2007. The study found that transformational and instructional leadership are perceived to be distributed among multiple leaders including Principal, Heads of Technology, and Heads of Subject. Heads of Technology are viewed as performing both transformational and instructional leadership activities more frequently than the Principal or the Subject Heads. The transformational leadership and instructional leadership performed have a significant effect on the amount of extra effort teachers put into their use of ICT.

Keywords Information communication technology · Distributed leadership · Transformational leadership · Instructional leadership · Empirical paper

Introduction

In the last decade, Singapore has committed two billion Singapore dollars in implementing two Masterplans for Information Communication Technology (ICT) in education for over 300 schools. The two Masterplans are "blueprint[s] for the use of ICT in schools and access to an ICT-enriched school environment for every child" (Ministry of Education Singapore 2005). These Masterplans included the provision of funding, training, technical support, and accessibility to technology for both teachers and students.

Since the launch of the second ICT Masterplan in 2002, all Singapore teachers have access to individual notebooks and ministry-provided email accounts. The student–computer ratio is approximately 5:1. All classes and schools are equipped with broadband access to the Internet, and every school has at least one Technology Assistant, with funding provided for schools to employ further technical assistants.

The position of the Head of Technology has been in place for a decade, as this position was implemented when the first Masterplan was launched in 1997. During the implementation of the first Masterplan, Heads of Technology were mainly involved in helping to set up and maintain the ICT infrastructure of the schools. In 2003, 1 year after the second Masterplan was launched; the role of the Head of Technology was redefined to focus on working with the Subject Heads to lead the integration of ICT into the curriculum. Correspondingly, Subject Heads of Instructional Programmes (HODs/IP) were expected to play a more prominent leadership role during the second Masterplan in integrating ICT into their respective subject areas (Ministry of Education Singapore 2003). For both Masterplans, Principals were expected to provide overall leadership in aligning the school's ICT plan with the school's strategic thrusts and direction.

How effective has this attempt to enlarge the leadership base for ICT been? Do teachers agree that leadership for ICT implementation has been provided by these various roles and what kinds of leadership are perceived to be performed? This article will discuss the survey findings of Singapore teachers with regard to their perception as to how leadership for ICT implementation in school is distributed among the HOD/ICT, HOD/IP and Principal.

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Literature Review

School Leadership in ICT Implementation

School leaders play a significant role in the implementation of ICT as concluded by an Organization for Economic Co-operation and Development (OECD study) that involved Singapore and 22 other countries. This study found that rapid diffusion of innovative ICT use "rarely occur[s], however, without adept school leadership" (Venezky and Davis 2002, p. 24). Indeed, "Diffusion can stall or retreat without appropriate leadership" (p. 24). The finding from this study that leadership is critical to the diffusion of ICT in educational innovations is supported by other research which examined organizational factors that impact the implementation of ICT in schools (Flanagan and Jacobsen 2003; Kincaid and Feldner 2002). The Apple Classroom of Tomorrow (ACOT) study found that leadership support was crucial in determining whether or not teachers persisted in changing their instructional approaches and thus the way students use technology, given technology-equipped classrooms and teachers who were trained in the use of technology (Sandholtz et al. 1997).

Although the literature indicates the importance of leadership for ICT implementation in schools, the bulk of the literature on technology leadership assumes that this leadership is provided mainly, if not solely, by the Principal (Bridges 2003; Creighton 2003; Inkster 1998; Martinez 2002; Schiller 2003; Yee 2000). However, as Anderson and Dexter (2005) noted, there is increasingly a need to apply the concept of distributed leadership to leadership for technology implementation in schools. They argued that distributed leadership is important because technology changes so rapidly and relevant expertise is distributed unevenly. Unfortunately, they did not explain in their paper what they meant by distributed leadership.

To date, there are few empirical studies on how leadership for technology implementation is distributed in schools. While Langran (2006) proposed that Principals and technology coordinators need to work together in providing leadership for technology reforms in schools, she did not provide details on how they worked together in practice. This study will examine the distribution of leadership for ICT implementation in Singapore schools. Our proposition is that leadership for ICT reforms in schools is distributed in two ways: numerically, based on designations, and qualitatively, based on the performance of key leadership functions.

Numerical Distribution of Leadership

Broadly speaking, distributed leadership shifts the focus from leadership performed by lone leaders to that performed by multiple leaders (Gronn 2002). This numerical, aggregated concept of distributed leadership is potentially more effective and sustainable than single-position leadership in supporting educational reforms (Muijs and Harris 2003; Weiss and Cambone 2000). Thus, the concept of distributed leadership is attractive since one of the major problems concerning ICT reform in schools, including Singapore schools, is the challenge of sustaining the reform (Looi et al. 2005).

Beyond leadership provided by the Principal, Kirkman (2000) observed that departmental leadership by Heads impacts teachers' innovative use of ICT to support their instructional practices, more so than individual teachers' ICT literacy or confidence in using ICT. Conversely, the same study observed how resistance and inaction by Subject Heads can have a profound negative impact on their teachers' use of ICT.

Another role that could potentially influence teachers' use of ICT is the Head of Technology, or its equivalent (Wagner et al. 2005). Some of the leadership activities identified as performed by Heads of Technology correspond with leadership activities associated with the Principal, such as the provision of professional development and modeling the use of technology (Flanagan and Jacobsen 2003). Certainly, Lawson and Comber (1999) noted the important leadership role of what they term the ICT coordinator. However, they also observed that the role of the ICT coordinator, while central, was not by itself a sufficient condition for successful ICT reform in schools. Lawson and Comber (1999) observed the need for support from senior management as well as the need for curriculum expertise to support the learning dimension of ICT use. Thus, while Lawson and Comber did not mention the concept of distributed leadership, their findings suggested that leadership for ICT reform is one that is shared among multiple individuals.

Distribution of Leadership by Functions

Besides a source-based distribution, Taylor (2004) observed that the distribution of leadership can be defined in terms of its configuration. Such an interpretation of distributed leadership views leadership as the performance of key functions, such as "selling a vision of the change" (Heller and Firestone 1995). These functions may be performed complementarily, redundantly, and implied more effectively by different people (Heller and Firestone 1995).

The challenge in considering leadership for ICT implementation is in deciding what constitute the key functions. Although the literature on technology reform in schools indicates discrete leadership actions which are important, no overarching leadership functions have been identified, possibly because this is a relatively new field.

While acknowledging the importance of distributed leadership (Anderson and Dexter 2005; Langran 2006), the literature on technology use in schools refers to distributed leadership almost as an aside, and there is no sustained discussion of this concept, whereas there is increasingly an interest in distributed leadership in the literature on leadership for schools. Thus, to consider leadership functions which may be relevant and useful to facilitate technology reform, there is a need to refer to the broader literature on leadership for schools.

Leithwood and Duke (1999), in their study of all articles on leadership for schools published in four major administration journals from 1985 to 1995, identified six distinct leadership functions:

(a) instructional (influencing teachers in ways that will impact students' learning)
(b) transformational (increasing the commitment and capacity of staff)
(c) moral (appealing to others by appealing to notions of right and wrong)
(d) participative (involving other members of the school community beyond the Principal)
(e) managerial (operating the school efficiently)
(f) contingent (adapting behavior to fit the situation).

Our contention is that of the six key leadership functions, instructional, and transformational leadership are more pertinent to leadership for an ICT reform in school

Instructional Leadership and Leadership for ICT Implementation

While there is no one definition of instructional leadership, there is consensus that the desired outcome of instructional leadership is to impact students' learning (Lashway 2003; Leithwood and Duke 1999). A comprehensive model of instructional leadership has been developed by Hallinger and Murphy (1985, 1986). This dominant model proposes three dimensions of the instructional leadership construct: defining the school's mission, managing the instructional program, and promoting a positive school-learning climate. These dimensions are further delineated into ten instructional leadership activities:

(1) framing the school's goals
(2) communicating the school's goals
(3) supervising and evaluating instruction
(4) coordinating the curriculum
(5) monitoring student progress
(6) protecting instructional time
(7) promoting professional development
(8) maintaining high visibility
(9) providing incentives for teachers
(10) providing incentives for learning (Hallinger and Murphy 1986).

Many of the leadership activities indicated in the literature as essential for effective technology implementation are similar to instructional leadership activities: envisioning opportunities for teaching and learning, providing professional development opportunities, promoting a sense of collegiality, modeling, coaching, encouraging examination of one's beliefs about teaching and learning, and experimentation with new instructional approaches (Hughes and Zachariah 2001; Lim et al. 2004). Indeed, Bennett (1996) described the Principal who can effectively integrate technology into the school curriculum as an instructional leader with the additional task of managing the technology. Similarly, Shuldman (2004) contend that it is difficult to be a technology leader without being an instructional leader. Unfortunately, the previous study is mainly prescriptive in nature while the latter is based on the perceptions of superintendents, rather than of the teachers who are the direct targets of the leadership provided. Thus, there is still a need to measure the teachers' perceptions of this leadership function and to determine which leadership sources are perceived as performing instructional leadership.

Transformational Leadership and Leadership for ICT Implementation

Besides instructional leadership, the other foremost leadership model, as measured by the number of empirical studies, is transformational leadership (Hallinger 2003; Heck and Wallace 1999). Transformational leadership focuses on developing the organization's capacity and commitment to innovate (Bass and Avolio 1994; Leithwood and Duke 1999).

Transformational leadership encourages teachers to innovate and reflect on their practices, which is identified in the literature on technology implementation as important for technology integration efforts to be successful (Hughes and Zachariah 2001). In a study conducted by Ng (2004) to investigate 50 pre-service teachers' perceptions of the influence of transformational leadership practices on the integration of ICT in teaching, the pre-service teachers moderately agreed that all the dimensions of transformational leadership practices had positive influence on the integration of ICT in teaching. Yuen et al. (2004) observed the need to fundamentally rethink the nature of education using ICT and the possible redesign of school processes. They noted that such change requires shifting transactional management to more transformational practices and leadership. Unfortunately, they did not elaborate on these transformational practices.

To date, there has been limited research on the role and effect of instructional and transformational leadership on schools' ICT implementation. The study by Ng (2004) most directly measures teachers' perceptions of transformational leadership with regard to ICT implementation but the findings of this study are limited to pre-service teachers. Besides Ng (2004), Feldner (2003) proposed that transformational leadership practices, as interpreted by Kouzes and Posner's (1987) Five Practices for Exemplary Leadership, may be related to the technology integration competences of teachers. Her findings, however, were based on self-assessment of leadership by Principals.

In summary, the literature suggests that both transformational and instructional leadership have a role to play in school technology reforms, but there is insufficient empirical research to support and elucidate this relationship. However, it is reasonable to suggest that leadership for technology implementation in schools requires a blend of both transformational and instructional leadership since the introduction of technology is meant to inspire *transformational changes* in instructional practices to *transform learning*. We agree with Marks and Printy (2003) that to successfully implement a reform which focuses on enhancing quality teaching and learning, leaders need to practice an "integrated form of leadership" (p. 376) involving *both* transformational and instructional leadership. Thus, this study sought to examine whether teachers perceive their leaders to be implementing transformational and instructional leadership (the key leadership functions) as well as how these leadership functions are distributed numerically among various leaders, based on their designations.

Research Questions and Hypotheses

The main research objective of the study is to examine how the two key leadership functions of instructional and transformational leadership are distributed among three leadership sources in ICT implementation in Singapore schools and how the performance of leadership by the three leaders affect teachers' commitment to use ICT in teaching and learning? The following hypotheses were posited:

Hypothesis 1 Transformational leadership is performed most frequently by the Principal.

In the literature on school leadership, transformational leadership, with its strategic focus on developing the organization's capacity and commitment to innovate, is most often associated with the Principal, despite recent arguments that transformational leadership is not and should not be restricted to those occupying formal administrative positions (Bush and Glover 2003; Harris 2005). We intended to examine if the Principal was the most frequent source of transformational leadership with regard to ICT implementation in Singapore schools.

Hypothesis 2 Instructional leadership is performed most frequently by the Subject Head.

While transformational leadership is still largely associated with the Principal, researchers acknowledge that the close monitoring and support expected of instructional leadership in the 1980s is not sustainable in recent times if performed solely by the Principal (Hallinger 2003). Nevertheless, this hands-on concept of instructional leadership is still important, particularly for ICT reforms which aim to transform instructional practices (Shuldman 2004). As the generic official roles of our Subject Heads resonate with the concept of instructional leadership, we wanted to examine if Subject Heads were the most frequent source of instructional leadership for ICT reforms in our schools.

Hypothesis 3 The higher the leaders' performance of transformational leadership, the higher the amount of extra effort teachers put into their use of ICT.

Hypothesis 4 The higher the leaders' performance of instructional leadership, the higher the amount of extra effort teachers put into their use of ICT.

Transformational leadership has traditionally been associated with an increase in staff's commitment toward school reform (Geijsel et al. 2003; Koh et al. 1995). However, the literature on instructional leadership suggests that instructional leadership can also positively impact teachers' commitment and willingness to innovate (Hallinger 2003; Marks and Printy 2003; Sheppard 1996). With respect to technology integration in schools, Hughes and Zachariah (2001) noted that for technology to be used successfully as an instructional tool in the classroom, teachers must be willing and able to construct pedagogically sound reasons for doing so, suggesting the importance of instructional leadership. Thus, it is important to examine the impact of both transformational and instructional leadership on teachers' willingness to commit to the use of ICT.

Methodology

Data Collection Method

An online survey was conducted from March to April 2007 to elicit teachers' perceptions of the leadership provided by the Principal, the Head of Technology and the Subject Head. An email was sent to the Principals of all primary and secondary schools (equivalent to K1–10) in Singapore

in early March 2007 to seek their assistance in encouraging their teachers to participate in the survey, which was voluntary in nature.

A total of 2,043 teachers (57 % from 76 Primary schools and 43 % from 69 Secondary schools) completed the survey. This constitutes about 43 % of Primary schools and 41 % of Secondary schools in Singapore. Based on the Education Statistics Digest 2006 (Ministry of Education 2006), which indicated a total of 23,838 staff (including Principals, Vice-Principals, and Heads), the number of survey participants constituted about 9 % of the teaching population. 77 % respondents were female and 23 % were male teachers. About 30 % of teachers had served in schools for <3 years, 40 % of them had served for 4–10 years, and another 30 % had served for more than 10 years.

The Survey Instrument

The survey contained items measuring instructional leadership (30 items) and transformational leadership (25 items), and outcome of leadership in terms of teachers exerting extra effort to use ICT (3 items). There were 58 items in total. For each leadership item, the teacher had to consider how frequently the leadership function identified was performed by the Principal, Head of Technology, and Subject Head over the past 1 year.

The items on instructional leadership were modified from Hallinger's Principal Instructional Management Rating Scale (PIMRS), which was first validated in 1982 and has subsequently been used in over 100 studies, for both elementary and secondary levels (Hallinger 2003). The original PIRMS provided a profile of the Principal's performance on ten instructional leadership functions (50 items). This study includes six of the original ten subscales (26 items), modified to apply to leadership for ICT implementation as opposed to leadership for the school in general: frame the school's IT goals (5 items), communicate the school's IT goals (3 items), supervise and evaluate instruction (5 items), co-ordinate the curriculum (4 items), promote professional development (5 items), and provide incentives for teachers (4 items). Four subscales (maintain high visibility, protect instructional time, monitor student progress, and provide incentives for learning) and some items within the six selected subscales were removed as they are more applicable to leadership at the whole school level or focused specifically on student learning in general. The bulk of the modifications involved relating the survey items specifically to ICT implementation in school. Table 1 shows the modification of selected questions, as well as selected questions which were removed.

Besides modifying existing items to be more directly relevant to leadership for ICT implementation in school, a new subscale was added to the instructional leadership construct: create time. This new subscale (4 items) was developed as lack of time is often mentioned in the literature and anecdotally by teachers in the field as a barrier to technology implementation in schools, suggesting the need to "create" time for teachers to develop, conduct, and share their ICT-based lessons (Anderson and Dexter 2005; Inkster 1998).

The items for transformational leadership were adapted from the Multifactor Leadership Questionnaire (MLQ) (Bass and Avolio 1990). The MLQ has been used to assess leaders at different managerial levels, in public and private organizations (including schools), and in different countries, including Singapore, Japan, India, and Spain. The MLQ consists of four subscales, including transformational leadership (37 items) and outcomes of leadership (9 items). For the purpose of this study, 25 transformational leadership items were modified to more specifically refer to leadership for ICT implementation in a school context. The modified transformational leadership section consists of four subscales: charisma (7 items), inspiration (6 items), intellectual stimulation (6 items), and individualized consideration (6 items). Items which appeared to be repetitive or too general in nature were removed. In addition, the stem was modified from first person to second person since the instrument was used by teachers to assess the leaders. Table 2 shows the modification of selected questions, as well as selected questions which were removed.

From the outcome subscale of the MLQ, the 3 items on Amount of Extra Effort were adapted to elicit from teachers how frequently their leaders impact the amount of effort that they put into using technology. Table 3 shows the original items and the reworded items.

Reliability tests were conducted for the instructional leadership construct, transformational construct, and amount of extra effort construct. The cronbach alpha values for the instructional leadership constructs ranged from .89 to .94, while cronbach alpha values for the transformational leadership constructs ranged from .94 to .97, for the Principal, the Head of Technology, and the Subject Head. The cronbach alpha reliability for the extra effort construct was .93 for the Principal, .92 for the Head of Technology, and .93 for the Subject Head.

Data Analysis

In the survey, teachers were asked to indicate the frequency with which they perceived their Principal, the Head of Technology, and their Subject Head to have performed specific transformational and instructional leadership functions over the previous year. Statistical analyses were conducted for the frequency of the two different types of leadership performed by the respective school administrators.

Table 1 Modification of the Principal Instructional Management Rating Scale (PIMRS)

Original Instrument	Modified Instrument
Frame the school's goals in terms of staff responsibilities for meeting them	Frame the school's ICT-related goals in terms of staff responsibilities for meeting them
Communicate the school's mission effectively to members of the school community	Communicate the school's ICT vision effectively to members of the school community
Review student work products when evaluating classroom instruction	Review student work products when evaluating ICT-based instruction
Compliment teachers privately for their efforts or performance	Compliment teachers privately for their effort or performance in using ICT
Ensure that students are not called to the office	Removed
Take time to talk with students and teachers during recess and breaks	Removed

Table 2 Modification of the Multifactor Leadership Questionnaire (MLQ)

Original Instrument	Modified Instrument
Show enthusiasm for what they [the teachers] need to do	Show enthusiasm for the use of ICT
I set high standards	Set high standards for the use of ICT
I let them know how they are doing	Let teachers know how they are doing with regard to the use of ICT
I require them to back up their opinions with good reasoning	Require teachers to back up their opinions on ICT use with good reasoning
I treat each of them as an individual	Removed
I give personal attention to those who seem neglected	Removed

Table 3 Modification of items on amount of extra effort

Original instrument	Modified instrument
I get them to do more than they expected they could do	Get teachers to do more with ICT than they expected they could do
I motivated them to do more than they thought they could do	Motivate teachers to do more with ICT than they thought they could do
I heighten their motivation to succeed	Heighten teachers' motivation to succeed in their use of ICT

Table 4 Comparison of teachers' perception of different leaders' performance of transformational leadership ($N = 2{,}043$)

	Principal		Head of technology		Subject head		Wilks's Λ	F	Partial η^2
	Mean	SD	Mean	SD	Mean	SD			
Charisma	3.28	.865	3.46	.826	3.27	.870	.053	12202.57**	.95
Inspiration	3.26	.857	3.43	.820	3.24	.862	.053	12164.06**	.95
Intellectual stimulation	3.14	.857	3.22	.815	3.14	.858	.060	10693.58**	.94
Individualised consideration	2.98	.888	3.24	.829	3.09	.876	.061	10526.08**	.94

** $p < .01$

Transformational Leadership across Different Leaders

Hypothesis 1 posits that transformational leadership will be performed most frequently by the Principal. To test this hypothesis, one-way repeated-measures ANOVA was conducted with the independent factor being the different positions of leaders and the dependent variable being the teachers' perceptions of each leader's performance of transformational leadership (Table 4).

The results in Table 4 indicate that there are significant differences among the teachers' perceptions of the different leaders' performance of transformational leadership. Significant differences were reported for charisma dimension, Wilk's $\Lambda = .053$, $F(2, 2041) = 12202.57$, $p < .01$, multivariate partial $\eta^2 = .95$; in inspiration dimension, Wilk's $\Lambda = .053$, $F(2, 2041) = 12164.06$, $p < .01$, multivariate partial $\eta^2 = .95$; in intellectual stimulation dimension, Wilk's $\Lambda = .060$, $F(2, 2041) = 10693.58$, $p < .01$, multivariate

Table 5 Paired samples test on transformational leadership across different leaders ($N = 2{,}043$)

	Paired differences		
	Mean	SD	t
Charisma			
Head of Technology vs. Subject Head	.19	.511	17.072**
Head of Technology vs. Principal	.18	.497	16.241**
Principal vs. Subject Head	−.01	.447	−1.451
Inspiration			
Head of Technology vs. Subject Head	.18	.492	16.693**
Head of Technology vs. Principal	.16	.486	15.307**
Principal vs. Subject Head	−.02	.461	−1.680
Intellectual stimulation			
Head of Technology vs. Subject Head	.08	.390	8.917**
Head of Technology vs. Principal	.08	.300	11.931**
Principal vs. Subject Head	.00	.424	.261
Individualized consideration			
Head of Technology vs. Subject Head	.15	.487	13.837**
Head of Technology vs. Principal	.26	.491	23.654**
Principal vs. Subject Head	.11	.475	10.253**

** $p < .01$

partial $\eta^2 = .94$; in individualized consideration dimension, Wilk's $\Lambda = .061$, $F(2, 2041) = 10526.768$, $p < .01$, multivariate partial $\eta^2 = .94$. As the ANOVA tests yielded significant effects, pairwise comparisons were conducted to assess which means differ from each other. The results of the analysis are shown in Table 5.

The follow-up paired sample t tests indicate that significant differences are found on all the four dimensions of transformational leadership between Subject Heads and Heads of Technology ($t = 17.072$, 16.693, 8.917, and 13.837, $p < .01$ for Charisma, Inspiration, Intellectual Stimulation, and Individualized Consideration, respectively), and between Heads of Technology and Principals ($t = 16.241$, 15.307, 11.931, and 23.654, $p < .01$ for Charisma, Inspiration, Intellectual Stimulation, and Individualized Consideration, respectively). No significant difference was found between Principals and Subject Heads except in individualized consideration dimension ($t = 10.253$, $p < .01$). The results show that teachers' perceptions of all four dimensions of transformational leadership performed by Heads of Technology are significantly higher than their perceptions of transformation leadership performed by Principals and Subject Heads. Therefore, Hypothesis 1 is not supported.

Instructional Leadership across Different Leaders

Hypothesis 2 posits that instructional leadership will be performed most frequently by the Head of Subject. To test this hypothesis, likewise, one-way repeated-measures ANOVA was conducted with the factor being the different position of leaders and the dependent variable being the teachers' perceptions of the leaders' performance of instructional leadership (Table 6).

The analysis indicates that there are significant differences among the teachers' perceptions of different administrator's performance of instructional leadership. Significant differences was reported in framing ICT goals, Wilk's $\Lambda = .043$, $F(2, 2041) = 15202.76$, $p < .01$, multivariate partial $\eta^2 = .96$; in communicating ICT goals, Wilk's $\Lambda = .053$, $F(2, 2041) = 11732.41$, $p < .01$, multivariate partial $\eta^2 = .95$; in supervising ICT-based instruction, Wilk's $\Lambda = .071$, $F(2, 2041) = 8916.61$, $p < .01$, multivariate partial $\eta^2 = .93$; in coordinating the curriculum to support use of ICT, Wilk's $\Lambda = .057$, $F(2, 2041) = 11298.58$, $p < .01$, multivariate partial $\eta^2 = .94$; in promoting the ICT-related professional development of staff, Wilk's $\Lambda = .046$, $F(2, 2041) = 14052.15$, $p < .01$, multivariate partial $\eta^2 = .95$; in providing incentives for teachers to use ICT, Wilk's $\Lambda = .085$, $F(2, 2041) = 7306.1118$, $p < .01$, multivariate partial $\eta^2 = .92$; and in creating time to support teachers' use of ICT, Wilk's $\Lambda = .073$, $F(2, 2041) = 8636.42$, $p < .01$, multivariate partial $\eta^2 = .93$. Pairwise comparisons were conducted to assess which means differ from each other. The results of the Pairwise comparisons are shown in Table 7.

The follow-up paired sample t tests indicate significant differences are found on all the dimensions of instructional leadership between Heads of Technology and Principals where Heads of Technology significantly performed these instructional leadership activities more frequently than Principals ($t = 17.064$, 14.295, 12.872, 17.572, 16.654, 4.814, and 6.142, $p < .01$, respectively). Comparing the specific dimensions of instructional leadership activities performed by Heads of Technology with instructional leadership performed by Subject Heads, it is found that Heads of Technology significantly performed all these instructional leadership activities except "Supervising ICT-based Instruction" ($t = 1.877$, $p > .05$) more frequently than Subject Heads ($t = 15.957$, 16.881, 12.005, 12.984, 6.557, and 5.886, $p < .01$, respectively). Comparing the specific dimensions of instructional leadership activities performed by Subject Heads with instructional leadership performed by Principals, it is found that Subject Heads communicated ICT goals to teachers more frequently than Principals do ($t = 4.028$, $p < .01$) whereas Principals significantly supervised ICT-based instruction ($t = 10.286$, $p < .01$), coordinated the curriculum to support use of ICT ($t = 5.472$, $p < .01$), and promoted the ICT-related professional development of staff ($t = 3.012$, $p < .01$) more frequently than Subject Heads do. Therefore, Hypothesis 2 is not supported.

Table 6 Comparison of teachers' perception of different leaders' performance of instructional leadership ($N = 2{,}043$)

	Principal		Head of Technology		Subject Head		Wilks's Λ	F	Partial η^2
	Mean	SD	Mean	SD	Mean	SD			
Frame ICT goals	3.44	.859	3.64	.786	3.44	.844	.043	15202.76**	.96
Communicate ICT goals	3.33	.899	3.50	.858	3.29	.913	.055	11732.41**	.95
Supervise ICT-based instruction	2.99	.925	3.11	.894	3.09	.881	.071	8916.61**	.93
Coordinate the curriculum to support use of ICT	3.23	.907	3.43	.859	3.29	.888	.057	11298.58**	.94
Promote the ICT-related professional development of staff	3.41	.848	3.59	.801	3.44	.837	.046	14052.15**	.95
Provide incentives for teachers to use ICT	2.93	.928	2.97	.926	2.91	.923	.085	7306.18**	.92
Create time to support teachers' use of ICT	3.00	.870	3.04	.867	3.01	.866	.073	8636.42**	.93

** $p < .01$

Table 7 Paired samples test on instructional leadership across different leaders ($N = 2{,}043$)

	Paired differences		
	Mean	SD	t
Frame ICT goals			
Head of Technology vs. Subject Head	.2036	.57677	15.957**
Head of Technology vs. Principal	.2078	.55050	17.064**
Principal vs. Subject Head	.0042	.53727	.354
Communicate ICT goals			
Head of Technology vs. Subject Head	.2181	.58410	16.881**
Head of Technology vs. Principal	.1700	.53755	14.295**
Principal vs. Subject Head	−.0481	.54007	−4.028**
Supervise ICT-based instruction			
Head of Technology vs. Subject Head	.0191	.45962	1.877
Head of Technology vs. Principal	.1245	.43725	12.872**
Principal vs. Subject Head	.1054	.46329	10.286**
Coordinate curriculum to support use of ICT			
Head of Technology vs. Subject Head	.1426	.53675	12.005**
Head of Technology vs. Principal	.2051	.52755	17.572**
Principal vs. Subject Head	.0625	.51654	5.472**
Promote ICT-related PD of staff			
Head of Technology vs. Subject Head	.1418	.49348	12.984**
Head of Technology vs. Principal	.1716	.46577	16.654**
Principal vs. Subject Head	.0299	.44803	3.012**
Provide incentives for teachers to use ICT			
Head of Technology vs. Subject Head	.0569	.39226	6.557**
Head of Technology vs. Principal	.0420	.39406	4.814**
Principal vs. Subject Head	−.0149	.39851	−1.693
Create time to support teachers' use of ICT			
Head of Technology vs. Subject Head	.0382	.29318	5.886**
Head of Technology vs. Principal	.0467	.34401	6.142**
Principal vs. Subject Head	.0086	.32840	1.179

** $p < .01$

In general, for both transformational and instructional leadership, the Head of Technology has the highest scores. The scores for all three leaders for both transformational and instructional leadership activities are positively and highly correlated ($p < .01$), with the correlation coefficient ranging from .752 to .943.

Table 8 Pearson correlation between transformational leadership and extra effort teachers put into their use of ICT ($N = 2{,}043$)

	Charisma		Inspiration		Stimulation		Consideration	
	r	r^2	r	r^2	r	r^2	r	r^2
Subject Head: effort	.802**	.643	.810**	.656	.836**	.699	.834**	.696
Technology Head: effort	.776**	.602	.790**	.624	.802**	.643	.815**	.664
Principal: effort	.798**	.637	.813**	.661	.834**	.696	.835**	.697

** $p < .01$

Table 9 Pearson correlation between instructional leadership and extra effort teachers put into their use of ICT ($N = 2{,}043$)

	Frame ICT goals		Communicate ICT goals		Supervise ICT-based instruction		Coordinate the curriculum to support use of ICT		Promote the ICT-related PD of staff		Provide incentives for teachers to use ICT		Create time to support teachers' use of ICT	
	r	r^2	r	r^2	r	r^2	r	r^2	r	r^2	r	r^2	r	r^2
Subject Head: effort	.607**	.368	.659**	.434	.658**	.433	.711**	.506	.722**	.521	.715**	.511	.691**	.477
Technology Head: effort	.555**	.308	.631**	.398	.609**	.371	.670**	.449	.676**	.457	.680**	.462	.668**	.446
Principal: effort	.601**	.361	.655**	.429	.642**	.412	.695**	.483	.704**	.496	.708**	.501	.698**	.487

** $p < .01$

Leadership Performance and Extra Effort Teachers Put Into Their Use of ICT

Hypothesis 3 postulates a positive relationship between performance of transformational leadership and the extra effort teachers put into their use of ICT—the higher the leaders' performance of transformational leadership, the higher the amount of extra effort teachers put into their use of ICT. Pearson correlation tests were employed to test this hypothesis. The results of Pearson correlation analyses are shown in Table 8.

As shown in Table 8, there are strong relationships between specific dimensions of transformational leadership and the extra effort that teachers put into their use of ICT. This finding is applicable to leadership performed by all the three administrators. All the Pearson correlation coefficients (r) are higher than .75 ($p < .01$) and all the coefficient of determination (r^2) are higher than .60, which means that more than 60 % of variance in extra effort teachers put into their use of ICT can be determined from its relationship with the transformational leadership performed by Subject Head, Head of Technology, and Principals. In general, the higher the Subject Head, Head of Technology, and Principals' performance of transformational leadership, the higher the amount of extra effort teachers tend to put into their use of ICT. Thus, Hypothesis 3 is supported.

Hypothesis 4 is that the higher the leaders' performance of instructional leadership, the higher the amount of extra effort teachers put into their use of ICT. Likewise, Pearson correlation tests were employed to test this hypothesis with the results shown in Table 9.

Discussion and Conclusion

In comparing the leadership activities performed by the Principal, Head of Technology, and Subject Head, our assumption was that the school Principal would most likely be the key leader performing transformational leadership. There are suggestions that the Principal is more likely to be involved in providing direction and engaging in symbolic activities and less likely to be involved in the day-to-day activity of leading instruction (Fidler 1997). Given the complexity involved in implementing an ICT reform, which requires an understanding of the subject, pedagogy, and the affordances of ICT for both the subject and the pedagogy (Pierson 2001), our argument is that leadership for ICT reforms needs to come from more than just the Principal.

In addition, our experience over the decade working with schools in implementing ICT reforms suggested the importance of the Subject Head in integrating ICT into a particular subject area. Our assumption was that the Subject Head would be the key leader exercising instructional leadership, an assumption consistent with the literature on middle management and teacher leadership (Katzenmeyer and Moller 2001).

The Head of Technology was the mystery variable as there was relatively little research on this position in the literature, particularly with regard to transformational or instructional leadership. Our experience with Heads of Technology suggested that in practice, they were preoccupied with maintaining infrastructure and hardware. When the survey was conducted, we were not sure whether the Head of Technology would be perceived as performing any leadership activities. We were not sure if this position served any purpose in terms of providing leadership for ICT reform.

Therefore, we were surprised by our finding that teachers generally perceived their Heads of Technology to be performing both transformational and instructional leadership activities more frequently than the Principal or the Subject Heads. Even with respect to supervision of ICT-based instruction, which we had expected the Subject Heads to be more actively involved in, the Head of Technology still scored higher than the Subject Head although the difference was not statistically significant.

Overall, the survey results support our proposition that leadership for ICT implementation in schools is distributed both numerically and qualitatively. Numerically, leadership for ICT implementation is distributed among multiple leaders, at the very least among the Principal, Subject Head, and Head of Technology. The significantly high correlations among the leadership performed by the three leaders further suggest that the leadership performed by one leader impacts the leadership of the other two leaders. Qualitatively, both transformational and instructional leadership are perceived to be performed by all three leaders. The high correlations among the scores of all three leaders lend support to the concept of "complementary redundancy" in which the same leadership functions are performed by people in different roles (Heller and Firestone 1995).

Another interesting finding is that while the literature tends to associate an increase in teachers' commitment to organizational goals with transformational leadership (Bass and Avolio 1994; Leithwood and Jantzi 2005; Lucas and Valentine 2002), with regard to teachers putting in extra effort for ICT, this outcome is highly correlated with both the transformational and instructional leadership items in our survey. This supports research which suggests that instructional leadership can itself be transformational in leading to teachers' growth in commitment and willingness to innovate (Hallinger 2003; Marks and Printy 2003; Sheppard 1996).

A limitation of the survey is that the teachers could have been affected by what they perceive as the "officially espoused" roles of the Head of Technology, which may not be an indication of the actual roles played by the Head of Technology. In addition, surveys can only provide insight into the numerical-based aspect of distributed leadership (Gronn 2002), or the dispersal of tasks among leaders (Harris 2005). To understand the holistic nature of distributed leadership, which involves interdependencies among those providing leadership (Gronn 2002), including those who are not holding official management positions, a more comprehensive qualitative study is necessary. Thus, this survey was followed up by a case study of an elementary school (K1–6) to provide a more complete understanding as to how and why leadership for ICT reform in schools is distributed.

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