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Teachers' Perceptions of the Dimensions and Implementation of Technology Leadership of Principals in Taiwanese Elementary Schools

I-Hua Chang, Joseph M. Chin
Department of Education, National Chengchi University, No. 64, Sec. 2, ZhiNan Rd., Taipei City 11605, Taiwan // Tel: +886-2-29387738 // Fax: +886-2-29387737 // ihchang@nccu.edu.tw // mcchin@nccu.edu.tw

Cheng-Mei Hsu
Graduate School of Design Doctoral Program, National Yunlin University of Science and Technology, No. 123, Sec. 3, University Rd., Douliou, Yunlin 64002, Taiwan // Tel: +886-2- 86613915 // Fax: +886-2-29609046 // g9330811@yuntech.edu.tw

ABSTRACT

Principals' technology leadership is strongly correlated with teachers' integration of educational technology, and technology leadership is necessary for effective utilization of technology in schooling. The article describes a study that empirically investigated teachers' perceptions of elementary schools principals' technology leadership practice in seven cities in Taiwan for understanding the implementation of technology leadership. This study used structural equation modeling with prospective data to test for model fit. The findings identified the four constructs (i.e., vision, staff development, infrastructure support, evaluation and research) comprising principals' technology leadership. The findings also show that interpersonal and communication skills are important antecedents to principals' overall effective technology leadership. Four themes (e.g., budget shortage, technology facilities, staff development, and leadership problems) which emerged from the transcript data were the practical problems that principals faced while they implemented technology leadership in their schools. The results suggest that principals who embrace technology will effectively lead their schools to acquire educational resources to enhance student engagement and learning.

Keywords

Elementary schools, Principal technology leadership, Technology integration, Technology literacy, Technology vision

Introduction

Technology development has historically facilitated progressive human civilization, improved living environments, and increased human welfare (Shen, 2004). With information technology development and innovation, computers, the Internet, and other information technologies are becoming important learning tools in students' everyday lives. Campus information technology utilization is designed to help students and improve educational quality. Therefore, developing student technology literacy is becoming increasingly important. Principals should possess basic information technology skills and literacy (Scott, 2005; Wexler, 1996) to support staff and faculty in preparing students to face information-age challenges. Technology Leadership Academies have been established in every U.S. state administrative office to provide curriculum projects for principals and administrators to stay in step with flourishing information technology development. In the modern information explosion environment, technology education becomes increasingly vital day by day, and principals with efficient technology leadership skills are the key to successful policies and technology education plans (Chang & Tseng, 2005).

The emerging technology leadership role means that principals cannot ignore campus technology management. Assuming a technology leadership role entails promoting technology literacy to prepare students for the information age. Principals' new leadership roles are becoming increasingly important in schools. Ross and Bailey (1996) indicate that as leaders who lay the educational foundation for their schools, principals have quickly become leaders who promote and support new educational technologies. More than ever, they are acting as facilitators of change who pursue new technological advancements and innovations that may benefit student achievement and learning. Thus, the principal's role becomes crucial in efforts to acquire and implement new educational technologies within [public] school settings.

Reeves (2004) conducted the National Leadership Evaluation Study from March 2002 to September 2002 with a nonrandom sample of 510 leaders, including district superintendents, central office administrators, and principals

from twenty-one U.S. states. The major dimensions for constructive leadership evaluation in his study included technology, faculty development, leadership development, and learning. The technology dimension consists of demonstrating the use of technology to improve teaching and learning, personal proficiency in electronic communication, and coherent management of technology resources, technology staff, and information. Based on the dimension and content of the technology mentioned, it is evident that school principals and administrators should pay attention to the technology issue.

The role of the principal has shifted from a narrow focus on management to a broader scope of leading student learning, reflecting the vision of building, facilitating, and supporting practices of leadership to create change and continual educational improvement in accountability-defined arenas (as cited in Orr & Barber, 2006). The dramatic change of the principal's role since the early 1980s has evolved from being primarily a building manager (Sharp & Walter, 1994), to an instructional and curriculum leader (Checkley, 2000; Cheng, 2004; Glatthorn, 2000; Huang, 2004; Wu, 2004), and more recently to a technology leader (Anderson & Dexter, 2005; Bailey & Lumley, 1994; Chang, 2002; Chang, 2003a, 2003b; Ford, 2000; Hsieh, 2004; Inkster, 1998; Kadela, 2002; Matthews, 2002; Ross & Bailey, 1996; Scott, 2005; Seay, 2004; Stegall, 1998; Yeh, 2003). New technology-related standards and performance indicators (e.g., leadership and vision; learning and teaching; productivity and professional practice; support, management, and operations; assessment and evaluation) for administrators have been developed, and principals' technology leadership roles have been explored as a means of improving student performance and supporting effective integration of technology into schools (Bridges, 2003; Hughes & Zachariah, 2001; ISTE, 2005; Kadela, 2002; Matthews, 2002; Seay, 2004).

Prior to relevant technology leadership research, which is gradually emerging (Battle, 2004; Bridges, 2003; Calhoun, 2004; Frazier, 2003; Hudanich, 2002; Martens, 2003; Mirra, 2004; Nash, 2002; Rogers, 2000; Scanga, 2004; Scott, 2005; Shuldman, 2003; Ury, 2003; Wagner, 2004; White, 2004), leadership theory evolved over the decades from trait theory, behavior styles theory, situational theory, and transformational theory to a new leadership paradigm. To cope with the leadership paradigm shift, scholars proposed new school leadership strategies including technology leadership, structure leadership, moral leadership, cultural leadership, symbolic leadership, human resource leadership, political leadership, and strategic leadership. The main responsibility of technology leadership, for example, is to identify the connections among technology, school vision, school mission, and educational policy. In other words, school leaders should understand the importance of computer and information technology for students as well as enrich the technology environment for student learning. Meanwhile, school leaders should empower, encourage, and collaborate with experts and local businesses to support campus-wide technology infrastructure (Chang, 2005). Information age school leaders should model technology leadership behaviors that promote teaching and learning to foster a learning environment in their organization. Principals should play a critical technology leadership role to create a learning culture.

Published in April 1983, *A Nation at Risk* called for reforms throughout the nation's K-12 educational system. The report specifically emphasized the need for students to become more technologically literate. Since then, a proliferation of educational technology policies and implementation plans has been launched in K-12 schools (Aten, 1996; U.S. Department of Education, 2001). Three prominent national reports serve as examples to illustrate these policy changes: (1) The Goals 2000: Educate America Act, placing educational technology in a prominent position (Glennan & Melmed, 1996); (2) Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge, releasing the nation's first educational technology plan (ED Office of Educational Technology, 2001); and (3) Enhancing Education Through Technology in No Child Left Behind (2001), unveiling a new educational technology plan (No Child Left Behind, 2001). These reports emphasized the importance of and need for educational technology in public education and suggested that with new technology policy implementation, the next generation of American children would be well prepared for the information age. Similarly, in Taiwan, information technology policy has been integrated into instruction in schools via programs that have been in place for a decade. In light of the importance of technology integration into school curricula and instruction, numerous technology literacy training initiatives have been implemented for teachers in Taiwan during the past decade. Additionally, technology literacy training programs and workshops have been offered to school administrators such as elementary and secondary school principals in Taipei City, Taichung City, and Kaohsiung City. Therefore, it is critical to investigate and evaluate the effectiveness of technology integration due to the government's huge investment in the programs mentioned above.

British research regarding technology leadership may be represented by Robinson (1994). According to Robinson, school administrators should support teachers in understanding the potential of technology while identifying applicable software and hardware. To this end, administrators ought to facilitate the exchange of ideas regarding uses of information technology through team teaching, the creation of work teams, work development checklists, and other resources or methods. Administrators should also evaluate the effectiveness of staff members in using information technology in order to identify staff members who require additional professional training. To provide practical training to principals of middle and elementary schools, the Hong Kong Education and Manpower Bureau designed a course to nurture future information technology leaders. The goal of the course was to foster the development of principals' knowledge and skills, while also helping them to understand the influence of information technology on pedagogy. The curriculum encouraged principals to initiate "a vision for information technology education in the school," understand "information technology leadership and organizing for strategic information technology," appraise and optimize "priorities in developing the school's information technology strategies," develop "a culture of collaborative learning through the internet" and "an edifying learning community, supporting the principal in integrating and utilizing appropriate information and communication technologies in pioneering novel pedagogies"(para. 1). At the same time, the course used academic focus groups to equip middle and elementary school principals with the following educational tools after completion of their learning courses: (1) the ability to pioneer a network of information technology education; (2) a profound understanding of the multidimensional aspects of state-of-the-art information technologies; (3) the ability to delineate information technology action plans for the new academic year; (4) a penchant for exploring applicable information technologies and learning/teaching models; (5) through personal observations and debates with others, the ability to utilize learning experiences from the training course to achieve the ultimate goal of reforming the curriculum by integrating information technology to the classroom; (6) an understanding of novel information technologies in the educational context (Centre for Information Technology in Education, 2005).

Technology leadership has been explored in the US since 1990. This body of research indicates that technology leadership has been defined in terms of concepts, indicators, nature, and behavioral characteristics, which emphasize that leadership in technology could be implemented as a function of innovations in schools. Compared to the volume of research regarding technology leadership in the U.S., there is little information detailing technology leadership in Taiwan. With relatively few studies specifically addressing evaluation of principals' technology leadership, this area necessitates future exploration so that current and future leaders can be prepared to deal more effectively with technology and to successfully implement technology policy.

The Purpose of the Study

Studies show that technology leadership can have a significant impact (Anderson & Dexter, 2005; Bridges, 2003; Inkster, 1998; Kozloski, 2006; Rogers, 2000; Weber, 2006; Yoho, 2006). Therefore, the purpose of this study is to empirically investigate teachers' perceptions of principals' technology leadership practices in seven different cities in Taiwan. Three primary questions will be addressed: (1) what are the dimensions of principals' technology leadership, (2) are the dimensions of principals' technology leadership perceived to be important to teachers; that is, do perceptions vary according to teacher demographic characteristics, and (3) what practical problems are faced by principals implementing technology leadership in their schools?

Theoretical Framework

Leadership is a key element for successful educational reform or innovation. For effective technology use in school districts' instructional programs, strong leadership must be provided at both the school and district level (Cory, 1990). Integrating educational technology into classroom instruction requires basic changes to current school models (Kinnaman, 1994), and principals must effectively model technology leadership (Ross, 1993). Principals are the key players in the educational change process (Ross & Bailey, 1996) and need to know the importance of effective school management and improving classroom instruction (MacNeil & Delafield, 1998). Thus, the principal's technology leadership proficiency is paramount to the current needs of public education.

Researchers have suggested that if school leaders are to help their institutions apply technology in beneficial ways, their leadership should: (1) empower the principal's team members (e.g., teachers, staff members), (2) identify the

principal's role during technology integration, (3) understand the interconnectedness and complexity of the principal's technology role, and (4) establish baseline information at the beginning of the principal's technology integration process (e.g., Bailey, 1997; Ford, 2000; Inkster, 1998; Kearsley & Lynch, 1994). Principals who effectively lead technology integration within their schools typically perform well in leadership and management, vision and goal setting, student learning, teaching, professional development and training, operations and infrastructure support, and assessment and evaluation (ISTE, 2001).

Effective leadership is a key element for the success of any educational innovation or new school instructional program (Cory, 1990). Effective principals should be actively involved in all aspects of educational technology (Inkster, 1998). Furthermore, Stegall (1998) suggests that principals' technology leadership is essential in elementary schools. A critical technology leadership element is the ability to develop and articulate a vision of how technology can produce educational change (Kearsley & Lynch, 1994). More importantly, technology leadership skills are necessary for principals to pursue new and emerging educational technologies for their schools (Bailey, 1997).

Recent educational literature is replete with studies related to technology leadership (Anderson & Dexter, 2000; Appalachia Educational Lab, 2000; Bailey, 1997; Brush, 1998; Ferris & Roberts, 1994; Jewell, 1998; Keating, Stanford, Self, & Monniot, 1999; Kowch & Walker, 1996; Robinson, 1994; Thomas & Knezek, 1991). For example, Aten (1996) stated that technology leadership supports effective instructional practices through a combination of interpersonal skills, knowledge of a variety of current technology applications, and the vision to anticipate future technology-based solutions for education. Murphy and Gunter (1997) also suggested that leadership should model and support computer technology to result in more effective curriculum integration of technology by teachers. Kearsley and Lynch (1994) noted that the manner in which technology is implemented is more important than any intrinsic educational process characteristics. They go on to say that technology is a powerful tool that supports school reform and facilitates student learning. The potential benefits of good leadership can include improved academic achievement by students, improved student attendance and reduced attrition, better vocational preparation of students, more efficient administrative operations, and reduced teacher/staff burnout and turnover. More than ever, principals play a critical role in implementing and improving technology education in their schools.

Drawing from the empirical literature on principals' leadership in general and, specifically, their effectiveness as technology leaders, five primary dimensions of principals' technology leadership will be examined and serve as the conceptual framework for this study: vision, planning, and management; staff development and training; technology and infrastructure support; evaluation and research; and interpersonal and communication skills. The aforementioned five dimensions were chosen because they are the principals' core tasks in dealing with teaching and learning as well as administrative operations with technology in their schools.

Vision and planning have been demonstrated to be very important technology leadership characteristics. Effective technology leadership develops and articulates a vision of how technology can produce school change (Cory, 1990). Developing such a vision requires principals to clearly understand district, state, and national trends and movements taking place with new and developing technologies. Inkster (1998) noted that creating a vision of how technology should be used by teachers and students is a significant indicator of a principal's technology leadership. Principals must have a clear technology vision and understand technology implications for the classroom. Without vision, staff members who lack direction and guidance for technology integration will not succeed (Ross & Bailey, 1996). Stakeholders (e.g., parents, community members, teachers, students) must also be involved in the school's technology vision. The greater the stakeholders' consensus and commitment, the more likely it is that the principal's technology vision and planning will become a reality (Jewell, 1998).

Staff development and training are important aspects of technology leadership. The most important responsibility identified by technology leaders was the ability to describe and identify resources for staff development (Ford, 2000). Effective staff training must consist of describing and identifying resources, and planning and customizing development programs based on individual and school needs. For example, the in-service plan should include listings and schedules of technology workshops and courses available to all administrators, educators, and support staff. Curriculum guidelines and effective technology leadership are also critical to the planning and designing of educational staff development activities (ISTE, 1998). To achieve an optimum staff development plan, principals need to identify key resources and players who can provide formal and informal leadership and technology support at every grade level and within every discipline to accomplish an effective instructional technology plan (Moursund, 1992).

Acquiring technology and supporting the infrastructure are crucial areas of technology leadership. Technology leaders need to provide service and technical support to their schools (Bailey, 1997). Principals, as technology leaders, must provide access to and the opportunity to acquire technology resources, as well as ensuring that appropriate facilities for technology are well supported (Collis, 1988). Assisting staff with a variety of issues such as purchasing appropriate software applications, troubleshooting equipment problems, installing equipment and infrastructure, maintaining and repairing equipment, understanding a variety of operating systems, and managing and allocating resources fairly and effectively are desired skills suggested for technology leaders (Aten, 1996; Ford, 2000). Providing and ensuring access to technology and maintaining infrastructure support were two areas most often identified as critical elements of principals' technology-related behaviors (Inkster, 1998).

Evaluation and research should be of primary concern to technology effectiveness. Effective principals implement evaluation procedures that allow for growth assessment of teachers and staff members toward established technology standards and help guide their professional development plans (ISTE, 2001). Principals should also include the learning and teaching process as a criterion in assessing instructional staff performance in the use and application of educational technology (ISTE, 2001). Cory (1990) suggests that because of the rapidly evolving nature of instructional and learning programs, it is particularly important that these programs are evaluated annually and the results incorporated into ongoing and future planning and assessment processes. Effective technology leadership should include evaluations of new and existing technology in terms of cost, benefits, and educational impact (Aten, 1996). Such evaluations provide principals with the appropriate information to effectively assess and improve technology plans in their schools.

Interpersonal and communication skills can impact principals' effective technology leadership. The ability to interact and communicate well is an important technology leadership characteristic (Aten, 1996; Inkster, 1998; Kline, 1993). Leaders must be able to get along with teachers and staff members as they begin to integrate new learning technologies (Bailey & Lumley, 1994; Jewell, 1998). A principal can be an effective leader without technological expertise; however, without interpersonal and communication skills, principals cannot be effective technology leaders. Technology leadership requires refined interpersonal and communication abilities, as well as technological competency (Ray, 1992). Principals' communication skills are often closely tied with their effective technology leadership (Inkster, 1998).

Research Method of the Primary Study

In order to investigate principals' role in facilitating technology use in U.S. schools, the author began to explore technology leadership dimensions in his 2002 doctoral dissertation (Chang, 2002), providing seven dimensions of technology leadership (i.e., vision, planning and management; in-service training; interpersonal and communication skills; ethical and legal issues; integrating technology into curriculum and learning; technological support and infrastructure; evaluation, research and assessment). In 2003, the author modified the previous research to include five dimensions of technology leadership. In his technology leadership model, interpersonal and communication skills are important antecedents to principals' overall effective technology leadership (Chang, 2003b). To further explore technology leadership development in Taiwan, the author revised the *Technology Leadership Questionnaire* consisting of thirty-nine items created in 2003 and applied the revised *Principals' Technology Leadership Questionnaire* to measure 434 teachers' perceptions regarding dimensions and implementation of principals' technology leadership in Taichung City, Taiwan (Chang, 2004). The author revised the *Principals' Technology Leadership Questionnaire* in 2005*,* expanded the sample size, and randomly sampled 1024 teachers selected from 188 elementary schools in seven cities in Taiwan. This was done to develop appropriate technology dimensions and technology standards for leaders in terms of school management and development. Providing an empirical measure of teachers' perceptions of principals' technology leadership is the primary purpose of this study. More specifically, this study proposes and develops a single level structural equation model to simultaneously define and measure the technology leadership construct.

Data Collection and Sample

The target population consisted of 1880 teachers (i.e., tenured teachers, mentor teachers, teachers serving as administrative staffs and directors) randomly selected from 188 elementary schools within the following seven cities

in Taiwan: Keelung City, Taipei City, Hsinchu City, Taichung City, Chiayi City, Tainan City, and Kaohsiung City. These cities are located in the northern, central, and southern parts of the island respectively, and this sample is indicative of the broader teaching population of Taiwan. Participants were selected after the pilot study, and a questionnaire was sent to each teacher along with a cover letter explaining the purpose of the study and providing needed information to properly complete the questionnaire. Teachers were asked to evaluate their principal's role in leading and facilitating technology use in their schools. To encourage the return rate, follow up thank you postcards and personal contacts were made until a satisfactory percentage of participants completed the questionnaire. More importantly, teachers were told that confidentiality was assured to alleviate teacher anonymity concerns. There were 188 schools of various sizes in the sampling. The schools were grouped according to the number of classes in each school and were placed the into following categories: 17 or below classes, 18-26 classes, 27-35 classes, 36-44 classes, 45-53 classes, 54-62 classes and 63 or above classes. 1880 questionnaires were sent to randomly selected classroom teachers and administrative staff. The sample is representative of the population (of school sizes in Taiwan). Of the 1880 questionnaires distributed, 1028 questionnaires were returned for a 55 percent response rate. Table 1 displays the demographic characteristics of the respondents. Demographic variables provide a descriptive profile of those individuals who responded to the survey.

Table 1. Number and Percent of Respondents by Demographics * N=1028

Demographics	Frequency	Percentage
Gender		
Male	366	35.6%
Female	618	60.1%
Age		
24 (or below) years old	34	3.3%
25-34 years old	396	38.5%
35-44 years old	400	38.9%
45-54 years old	169	16.4%
55 (or above) years old	24	2.3%
School Size (N of class)		
17 (or below) classes	114	11.1%
18-26 classes	84	8.2%
27-35 classes	99	9.6%
36-44 classes	213	20.7%
45-53 classes	167	16.2%
54-62 classes	45	4.4%
63 (or above) classes	301	29.3%
Teaching Year		
5 (or blew) years	234	22.8%
6-10 years	205	19.9%
11-20 years	350	34.0%
21-30 years	187	18.2%
31 (or above)	42	4.1%
Educational Level		
Senior College	24	2.3%
BA or BS	211	20.5%
BA or BS (from teacher college or normal university)	549	53.4%
M.A. or M.Ed.	228	22.2%
Ph.D. or Ed.D.	1	0.1%
Position		
Mentor Teacher	370	36.0%
Specialist Teacher	128	12.5%
Administrative Head	345	33.6%
Director	165	16.1%

* Numbers and percentages in the categories may not total 100 due to some missing data.

Using SPSS, the descriptive statistics of demographic variables were calculated. Of those teachers who responded to the demographic information on the instrument, respondent gender consisted of 366 (35.6%) males and 618 (60.1%)

females; respondent age ranged from 25 to 55, and most (400, or 38.9%) respondents were between 35 to 44 years. School size consisted of 301 (29.3%) with schools with 63 or more classes. Years of teaching experience varied, with 234 (22.8%) with less than 5 years, 205 (19.9%) with 6-10 years, and 350 (34.0%) with 11-20 years. Five hundred forty nine respondents (53.4%) held a BA from a teacher college or normal university, 228 (22.2%) held an MA or M. Ed. Three hundred seventy (36.0%) respondents identified themselves as mentor teachers, and 345 (33.6%) teachers were serving as administrative heads.

The instrument of this study, Elementary School Principals' Technology Leadership Questionnaire, was revised from The Dimensions and Implementation of the Elementary School Principals' Technology Leadership Questionnaire (Chin & Chang, 2006). It is conceptualized as four inter-related dimensions: (1) vision, planning and management (e.g., articulating a shared vision for technology use, developing a shared vision and long-range technology plan, using technology to efficiently manage administrative operations); (2) staff development and training (e.g., providing in-service training for specific skill acquisition, allocating resources for in-service training); (3) technology and infrastructure support (e.g., advocating adequate technology support , seeking out external funding sources for technology); and (4) evaluation, research, and assessment (e.g., implementing evaluation procedures for teachers' professional growth in technology, evaluating technology use in instructional programs).

Thirty-one Likert-type items (5-point scales) comprised the four dimensions that were hypothesized to define and measure principals' technology leadership. A response of "1" indicates that the principal never facilitates technology use in school, and a response of "5" indicates that the principal very often facilitates technology use in school. Based on the preliminary analysis, the four leadership dimensions showed consistency across the individual groups of assessment responses. The alpha coefficients (shown in parentheses) were calculated for each scale: vision, planning and management (.954); staff development and training (.945); technology and infrastructure support (.945); and evaluation and research (.955).

In addition to the four dimensions, the intervening construct representing principals' interpersonal and communication skills (e.g., demonstrating and maintaining positive relationships, understanding teacher needs and concerns) consisted of eight scaled leadership items and was also internally consistent across teacher groups (.966). Respondent demographics were also included on the instrument (e.g., gender, age, school size, teaching year, educational background, position, and school area). Five factors were extracted using Varimax Rotation from the original instrument, *The Dimensions and Implementation of the Elementary School Principals' Technology Leadership Questionnaire*. The variance factors were as follows: 64.652% (evaluation and research), 3.543% (vision, planning and management), 3.341% (interpersonal and communication skills), 2.859% (technology and infrastructure support), and 2.637% (staff development and training).

Data Analysis

Empirical measurement of the dimensions and implementation of principals' technology leadership related to principals' effectiveness as perceived by their teachers in Taiwan is the intent of this study. The final structural equation model (SEM) was conducted using LISREL 8.52 (Question 1) to verify that interpersonal and communication skills are important antecedents to principals' overall effective technology leadership. SPSS was used to calculate means, standard deviations, and scale reliabilities (Cronbach's alpha). *T*-tests and analysis of variance (ANOVA) were performed to determine differences in teachers' technology leadership ratings based on teacher characteristics (Question 2). Finally, a qualitative thematic strategy was employed to analyze the practical problems that principals faced (Question 3).

Findings and Discussion

SEM provides researchers with the ability to simultaneously define and measure multidimensional constructs (e.g., principals' technology leadership). The fit of the proposed model to the data was assessed by SEM fit indices. The chi-square value is 686.44 with 201 degrees of freedom and is significant (p=.00). The GFI, SRMR, RMSEA, NNFI, CFI, and PNFI values are .94, .034, .048, .99, .99 and .86 respectively. The Critical N is 363.14. The results of these common fit indices clearly indicate that the proposed model fit these observed data well. Table 2 displays the goodness of fit indices for the final model.

Table 2. Goodness of fit indices for the final model

Fit index	Acceptable fit	Result
Degree of Freedom=201		
Chi Square	Non-significant	686.44 (p = .01)
GFI	> .90	.94
SRMR	> .05	.034
RMSEA	> .05	.048
NNFI	> .90	.99
CFI	> .90	.99
PNFI	> .50	.86
Critical N	> 200	363.14

After ensuring that the proposed model fit the data, standardized parameter estimates in the model were considered. The four constructs (i.e., vision, staff, support, research) comprising principals' technology leadership define and measure the proposed model well, and all parameter estimates were significant (.86, .83, .86, .81, respectively) as shown in Figure 1. The results suggest that the observed data and the proposed model fit these data quite well; that is, the dimensions defined effective technology leadership well. In other words, vision, planning, and management; staff development and training; technology and infrastructure support; and evaluation and research are the four dimensions of behavior that explain the effective technology leadership of principals.

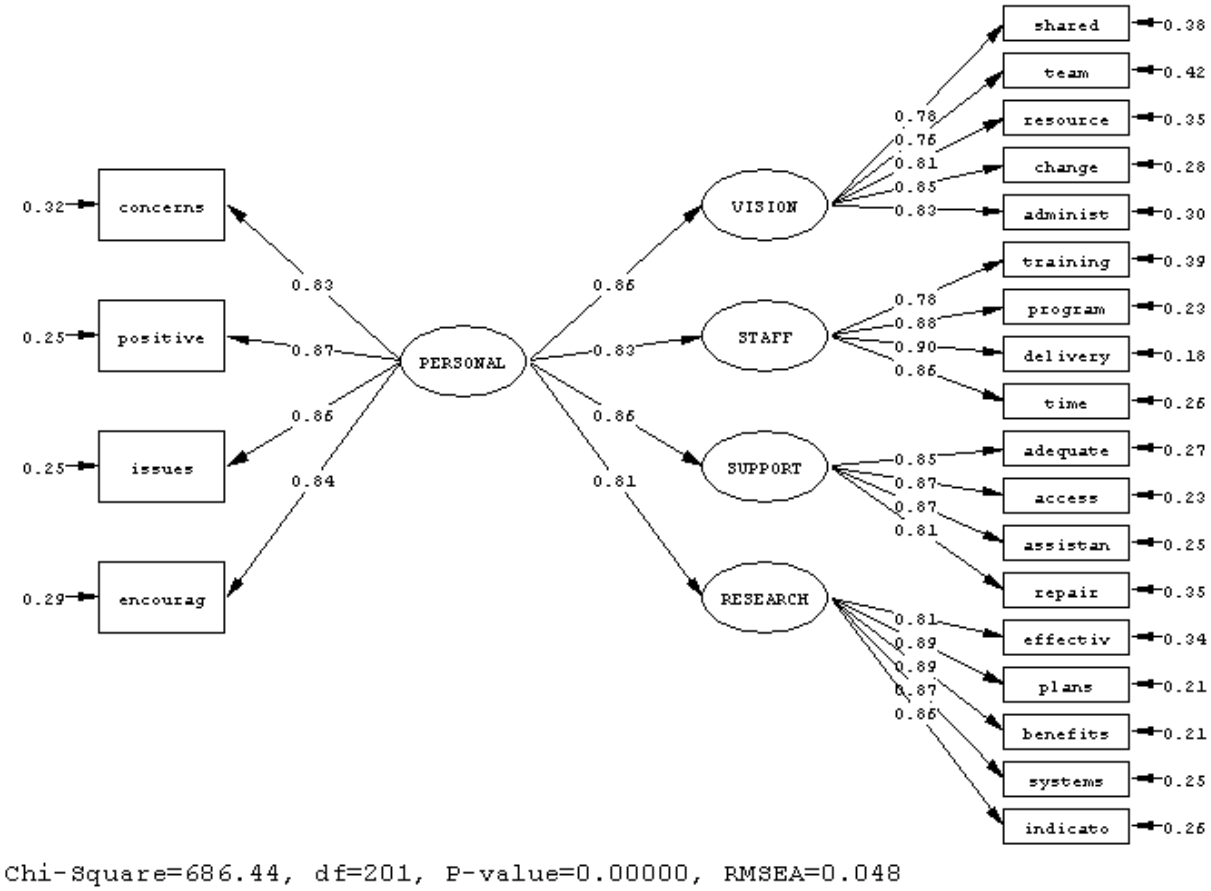

Figure 1. The model of principals' technology leadership

These results indicate that principals need to develop and implement a visionary long-range technology plan in order to be effective technology leaders. The findings also show the importance to principals of staff development and training activities for their teachers and students. Principals must also ensure that the school's technology infrastructure is well supported, and as leaders of technology they must develop an evaluation and assessment plan for their schools. These dimensions of behavior significantly explain principals' effective technology leadership.

Principals' interpersonal and communication skills showed a significant and positive impact on teachers' perceptions of principals' effective technology leadership. This finding supports previous research (Chang, 2002) showing that to become effective technology leaders, principals must build positive working relationships, communicate change and new ideas well, and identify and support teacher needs and concerns. As technology leaders, principals who embrace technology will effectively lead their schools to acquire educational resources to enhance student engagement and learning. Drawn from Figure 1, the dimensions and performance indicators of principals' technology leadership are shown in Table 3.

Table 3. The Dimensions and Performance Indicators of Principals' Technology Leadership

Dimension	Performance Indicator
Vision, Planning and Management	1. Clearly articulates a shared vision for technology use in the school
	2. Empowers a diverse and inclusive technology planning team
	3. Advocates for school technology resources
	4. Manages technology change effectively
	5. Uses technology to efficiently manage administrative operations
Staff Development and Training	1. Encourages technology in-service training
	2. Supports technology in-service training program design
	3. Supports technology in-service training delivery
	4. Provides technology training release time
Technology and Infrastructure Support	1. Ensures appropriate technology facilities
	2. Ensures equal access to technology resources
	3. Ensures technology support to school personnel when assistance is needed
	4. Ensures equipment timely repair and maintenance
Evaluation and Research	1. Considers effective technology use as one performance assessment component of instructional staff
	2. Evaluates school technology plans
	3. Evaluates technology in terms of costs/benefits
	4. Evaluates computer operating systems for classrooms and laboratories
	5. Utilizes district level data to evaluate technology instructional use
Interpersonal and Communication Skills	1. Demonstrates an understanding of technology needs and concerns of faculty, staff and students
	2. Maintains positive relationships with faculty, staff and students in regard to technology
	3. Communicates effectively with faculty, staff, and students about technology
	4. Encourages school personnel to utilize information sources about technology for professional development

Teacher demographic characteristics (e.g., gender, age, school size, teaching year, position and school area) and ratings of the four-technology leadership dimensions (e.g., vision, staff, support, and research) were significantly related at the .05 alpha level, as shown by t-test and ANOVA results. Table 4 displays the mean and standard deviation of the dimensions of technology leadership. Among the five dimensions analyzed, the mean of "*Interpersonal and Communication Skills*" (Mean=3.929, SD=.736) was highest, with the other dimensions as follows: *Technology and Infrastructure Support* (Mean=3.913, SD=.747), *Staff Development and Training* (Mean=3.775, SD=.758), *Vision, Planning and Management* (Mean=3.758, SD=.724) and *Evaluation and Research* (Mean=3.521, SD=.787). Teachers' perceptions of principals' technology leadership implementation were positive, based on overall analysis.

Table 4. Mean and standard deviation of the dimensions of technology leadership

Dimension	Mean	Standard Deviation
Interpersonal and Communication Skills	3.929	0.736
Technology and Infrastructure Support	3.913	0.747
Staff Development and Training	3.775	0.758
Vision, Planning and Management	3.758	0.724
Evaluation and Research	3.521	0.787

Demographic and environmental variables, including age, school size, teaching years, educational level, position, and school area were significant (t test and ANOVA) except for the educational level variable. Tables 5 to 9 display the analysis of variance for demographic and environmental variables on the dimensions of technology leadership.

Table 5. Analysis of Variance for Age on the Dimensions of Technology Leadership

		Sum of Squares	df	Mean Square	F	Sig.
Vision	Between Groups	10.155	4	2.539	4.976	.001
	Within Groups	495.874	972	.510		
	Total	506.029	976			
Training	Between Groups	15.008	4	3.752	6.865	.000
	Within Groups	537.235	983	.547		
	Total	552.242	987			
Support	Between Groups	9.251	4	2.313	4.375	.002
	Within Groups	516.430	977	.529		
	Total	525.680	981			
Evaluation	Between Groups	10.980	4	2.745	4.602	.001
	Within Groups	581.518	975	.596		
	Total	592.498	979			
Skill	Between Groups	12.844	4	3.211	6.106	.000
	Within Groups	517.441	984	.526		
	Total	530.285	988			

Table 6. Analysis of Variance for School Size on the Dimensions of Technology Leadership

		Sum of Squares	df	Mean Square	F	Sig.
Vision	Between Groups	7.530	6	1.255	2.446	.024
	Within Groups	497.272	969	.513		
	Total	504.802	975			
Support	Between Groups	9.208	6	1.535	2.900	.008
	Within Groups	516.054	975	.529		
	Total	525.262	981			
Evaluation	Between Groups	7.931	6	1.322	2.203	.041
	Within Groups	583.859	973	.600		
	Total	591.790	979			
Skill	Between Groups	10.573	6	1.762	3.342	.003
	Within Groups	517.805	982	.527		
	Total	528.378	988			

Table 7. Analysis of Variance for Teaching Year on the Dimensions of Technology Leadership

		Sum of Squares	df	Mean Square	F	Sig.
Vision	Between Groups	13.510	4	3.377	6.667	.000
	Within Groups	489.344	966	.507		
	Total	502.854	970			
Training	Between Groups	19.633	4	4.908	9.067	.000
	Within Groups	529.410	978	.541		
	Total	549.042	982			
Support	Between Groups	7.254	4	1.814	3.410	.009
	Within Groups	516.934	972	.532		
	Total	524.188	976			
Evaluation	Between Groups	11.251	4	2.813	4.710	.001
	Within Groups	579.316	970	.597		
	Total	590.567	974			
Skill	Between Groups	15.446	4	3.861	7.384	.000
	Within Groups	511.986	979	.523		
	Total	527.432	983			

Table 8. Analysis of Variance for Position on the Dimensions of Technology Leadership

		Sum of Squares	df	Mean Square	F	Sig.
Vision	Between Groups	8.625	3	2.875	5.624	.001
	Within Groups	490.792	960	.511		
	Total	499.417	963			
Training	Between Groups	18.371	3	6.124	11.290	.000
	Within Groups	527.222	972	.542		
	Total	545.593	975			
Support	Between Groups	15.069	3	5.023	9.613	.000
	Within Groups	504.742	966	.523		
	Total	519.811	969			
Evaluation	Between Groups	8.561	3	2.854	4.784	.003
	Within Groups	575.029	964	.597		
	Total	583.590	967			
Skill	Between Groups	12.418	3	4.139	7.868	.000
	Within Groups	512.431	974	.526		
	Total	524.849	977			

Table 9. Analysis of Variance for School Area on the Dimensions of Technology Leadership

		Sum of Squares	df	Mean Square	F	Sig.
Vision	Between Groups	11.750	3	3.917	7.690	.000
	Within Groups	484.877	952	.509		
	Total	496.628	955			
Training	Between Groups	7.039	3	2.346	4.205	.006
	Within Groups	537.940	964	.558		
	Total	544.978	967			
Support	Between Groups	9.107	3	3.036	5.775	.001
	Within Groups	504.124	959	.526		
	Total	513.231	962			
Evaluation	Between Groups	15.979	3	5.326	9.092	.000
	Within Groups	561.801	959	.586		
	Total	577.779	962			
Skill	Between Groups	5.685	3	1.895	3.580	.014
	Within Groups	510.840	965	.529		
	Total	516.525	968			

Each study participant in the questionnaire was also asked, "*What's your opinion regarding your principal's role in facilitating technology use in your school?*" Using open and axial coding techniques, participants' answers (transcripts) were thematically aggregated for important emerging category analysis. Four themes emerged from the transcript data: budget shortage problems, technology facility problems, staff development problems, and leadership problems. Schools are frequently faced with budget shortages. Teachers recommended that their principals raise technology funds. For example, teachers replied:

> Our classrooms should have Internet connections and computer equipment set ups; integrating instructional technology is the intent, but insufficient funds result in insufficient equipment; therefore principals should raise funds for computer upgrades.

Participants also recommended that principals seek out external funding sources to provide applicable technology equipment. For example:

> Principals should seek out external support and technology funding resources in Order to upgrade technology equipment and provide adequate technology to school members.

Expenditure was associated with the problems principals encountered with technology facilities. Expense directly influenced the availability of adequate facilities, which impacted technology use. Principals, according to respondents, should provide instructional equipment, hardware and software to meet faculty and student needs. For example, participants responded:

> It is necessary to evaluate classroom projector needs; hardware and software should be regularly upgraded, and faculty and students should have unlimited access to facilities; insufficient instructional facilities and dysfunctional multimedia should be improved; computer and peripheral equipment (e.g., Internet connection, printer, instructional software) should be provided for each grade.

Teachers also indicated that schools should ensure that technology facilities were appropriate for instruction and learning. For example:

> Teachers could not integrate technology into classroom instruction due to insufficient equipment. Schools should remodel infrastructures to facilitate teacher's professional technology development.

One participant, talking about his school, positively commented:

> Two laser pointers, a printer, and an ink cartridge were provided to each teacher for convenience in utilizing audio and video equipment.

Staff development problems encountered by principals were associated with teachers' technology literacy, which was correlated with in-service training. Participants replied that schools should provide technology workshops for in-service teachers. For example:

> In order to promote teachers' technology literacy, technology workshops should be offered; principals should play an advocacy role and hold a series of school-based technology workshops to facilitate technology use.

Teachers also pointed out cases where their schools promoted teachers' technology literacy. For example:

> I appreciated my principal's support in helping teachers integrate technology into instruction, creating websites, and handling student affairs; our principal prioritized computer instruction as the key feature of students' curriculum, and our building had sufficient equipment. The principal also demonstrated an understanding of faculty, staff, and student technology needs and concerns.

Principals' leadership responsibilities are to lead and support. For example, teachers stated that:

> Principals should implement their leadership roles and strengthen their technology capacity; our principals advocated adequate technology support, and encouraged faculty and students to use technology.

One participant expressed that principals do not necessary need to be technology specialists. For example:

> A principal must empower his team members to manage technology, seek out external technology resources, and encourage faculty technology use instead of becoming a technology specialist.

Based on the aforementioned findings, elementary principal technology leadership has been defined and measured as one construct comprising four technology leadership dimensions (i.e., vision, planning, and management; staff development and training; technology and infrastructure support; evaluation and research). The first dimension, vision, planning, and management, implies that, as technology leaders, principals should clearly articulate a shared technology vision for their schools. Previous research shows that articulating, sharing, and demonstrating a technology vision for the schools are necessary effective leadership behaviors (Aten, 1996; Cory, 1990; Ford, 2000; Inkster, 1998; Jewell, 1998; Ray, 1992). Furthermore, organizing and empowering a technology-planning team are important vision and planning responsibilities for teachers' technology leadership perceptions. Managing technology resources effectively is also an essential for principals. This study supports previous research in that vision, planning, and managing technology resources are critical elements to principal overall technology leadership. Therefore, effective principals should advocate for school technology resources, exercise fair and reasonable judgment in allocating technology funds and resources, implement a reasonable technology plan, and manage technology facilities and resources well.

The second dimension**,** staff development and training, suggests that principals should help train and encourage teacher's technology development. Staff technology development and training is an essential aspect of principals' technology leadership. To demonstrate technology leadership effectively, principals should encourage teachers' technology skill acquisition, plan and design on-going and future technology staff development programs, and provide teachers adequate time for technology training. Staff development and training significantly explained principal technology leadership in this case. These findings also support Spence's (1999) (as cited in Ford, 2000)

study examining principals' technology leadership competencies. He argued that identifying and coordinating appropriate staff development activities was listed as the single most important technology leader responsibility. Similarly, Aten's (1996) study showed that staff development was the number one skill most needed. Teachers highly value technical assistance in developing and nurturing technology skills. This study also supports previous research that staff development and training is an important principal technology leadership characteristic.

The third dimension, technology and infrastructure support, argues that principals need to provide adequate technology support. Acquiring technology, as well as maintaining and supporting school infrastructure, are crucial areas of principals' technology leadership. Principals, as technology leaders, must ensure appropriate technology facilities, provide access to technology resources, and support school personnel when technical assistance is needed. Principals must ensure timely repair and maintenance of equipment in their schools. Technology dimension and infrastructure support significantly explained principal's effective technology leadership in this study. Simply put, advocating adequate technology and infrastructure support for school members (e.g., teachers, staff members, and students) are important principal technology leadership characteristics.

The fourth dimension, evaluation and research, suggests that principals as technology leaders should consider technology use as one component in instructional staff performance assessment. They also need to evaluate school technology plans in terms of costs/benefits, and monitor computer operating systems in both classrooms and laboratories. More importantly, principals should also utilize district level data to evaluate instructional technology use. Furthermore, comparing school data with district and national data can often provide ideas, trends, and successes [failures] applicable to school performance and effectiveness improvement. Evaluation and research significantly contributed to overall principal technology leadership in this study. This dimension reflects previous research showing important principal technology leadership characteristics. Principals as technology leaders also need strong interpersonal and communication skills to be effective. They should demonstrate an understanding of technology needs and concerns of teachers, staff members, and students. More important, it is imperative that principals maintain positive and constructive interpersonal relationships, and communicate effectively with their teachers, staff and students, and encourage school personnel to utilize technology information sources for professional growth.

Conclusions and Implications

Researchers have recently turned to the study of technology leadership in terms of technology's support of school reform. Application of leadership skills necessary for school leaders to help their institutions apply technology in beneficial ways and prepare their schools for the 21st century is the meaning of technology leadership. Researchers have stated that building principals' technology leadership is essential in schools; principals must model effective technology leadership. In this study, effective technology leadership of principals has been defined and measured as one construct comprising four dimensions (domains). The method used in this study, Structural Equation Modeling (SEM), offers an advancement in the ability to define the multidimensional technology leadership construct. In this case, effective technology leadership of principals was quite well defined and well measured. A technology leader is one who leads the school in improvement on restructuring, and uses emerging technologies as the core resources for educational change. More importantly, the role of principal is now evolving to that of a technology leader. To be an effective technology leader, a principal should develop and implement a technology vision and long-range technology plan in the school. A principal requires a sense of vision, since technology leadership is the ability to develop and articulate a vision of how technology can produce change. Moreover, a principal should encourage faculty development in technology. Principals should plan and design staff development activities for their school settings. Beyond that, advocating technological support, ensuring that facilities for technology use are adequate, and evaluating school and district technology plans are the roles and responsibilities of the principal as technology leader.

The paper is significant since numerous technology literacy-training initiatives have been implemented for teachers in Taiwan during the past decade. With relatively few studies specifically addressing evaluation of building principals' technology leadership in Taiwan, this is an area that necessitates future exploration so that current and future leaders can be prepared to deal more effectively with technology and can be expected to successfully implement technology policy. The evaluative instrument and process for assessing technology leadership discussed has merit. More importantly, the paper extends work in the technology field, and the paper offers the alternative

points of view that interpersonal and communication skills are important antecedents to principals' overall effective technology leadership. The aforementioned finding makes a significant contribution to the field.

Implications for Theory

Although there is an abundance of studies related to technology leadership in the educational literature, few studies have focused on measuring principals' effective technology leadership as perceived by their teachers. The findings from this study support the idea that effective technology leadership of principals can be empirically defined and measured. The effective technology leadership constructs reported in this study both support and add to previous research findings.

Implications for Single Level Analysis in Leadership Studies

Previous studies on technology leadership focused on descriptive statistical analysis. A challenge to this study was employing the technique of Structural Equation Modeling. Structural Equation Modeling offers advancement in the ability to simultaneously define multidimensional constructs such as technology leadership and also to test for direct and indirect effects of technology leadership performance on principals' effectiveness. As proposed in this study, an SEM covariance structure analysis can be extended to include sets of predictors at the individual level. The results of this study show that SEM is a powerful means of defining and measuring multidimensional constructs of technology leadership.

Implications for Practice and Policy

Much current research notes that the principal's role has evolved to that of an effective technology leader. Moreover, researchers have shown that principals' technology leadership is essential in schools. As this study indicates, principals as technology leaders must develop and implement a school vision and technology plan, encourage teacher technology development and training, provide adequate infrastructure and technology support, and develop an effective school evaluation plan. Principals who embrace their evolving role as technology leaders can effectively lead and prepare their schools. More than ever, principals must lead their schools in acquiring and using new and emerging technologies as educational resources for enhanced student engagement and learning. The four technology leadership dimensions examined in this study provide principals with the knowledge and skills necessary to use technology and enhance their effectiveness as school leaders. Moreover, this evaluation instrument may provide educational administrators with substantive information to enhance the recruitment and selection of principals as technology leaders. As a result of this evaluation and assessment information, Taiwan's Department of Education could sponsor preparation programs providing professional development for principals to improve classroom technology use, evaluate teacher and student strengths and needs in technology, and develop a practical and useful technology plan. Increased student learning and achievement through the application of new and emerging educational technologies is the primary goal.

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