Exploring critical aspects of information technologies integration in Singapore schools

Lim Cher Ping, Khine Myint Swe, Timothy Hew,
Philip Wong, Divaharan Shanti
Nanyang Technological University

Betsy Lim
Ministry of Education, Singapore

This paper reports the key findings of a questionnaire survey aimed at exploring the critical aspects of information technology (IT) integration in Singapore schools. The survey is the first part (Phase 1) of a larger study funded by the Ministry of Education (MOE), Singapore, to analyse where and how IT mediates pupils' higher order thinking skills in schools. 328 schools (87.2% of the target population of 376 schools) responded to the questionnaire. Based on the findings, three recommendations are made concerning:

1. IT-integration models for Singapore schools;
2. Exploring new strategies for pupil IT competency development in selected government and government aided schools; and
3. IT competency standards for teachers and pupils.

Background of main study

The primary motivation for integrating IT in education is the belief that it supports pupils in their own constructive thinking, allows them to transcend their cognitive limitations, and engages them in cognitive operations that they may not have been capable of otherwise (Salomon, 1993). Most countries in the world have an existing blueprint for the integration of IT in schools. In Singapore, the Masterplan for IT in Education was launched in April 1997 and has clearly spelt out how IT is to be used and integrated in education as a strategy to meet the challenges of the future. As part of this plan, all Singapore schools are expected to acquire and integrate IT in their curriculum so as to develop a culture of thinking, lifelong learning and social responsibility (Ministry of Education, 1997).

The IT Masterplan was implemented in three phases: Phase I in 1997, Phase II in 1998, and Phase III in 1999. Schools that had a good history in the use of IT in their curriculum were chosen to be the demonstration schools. These demonstration schools, known as Phase I schools, would provide the rest of the schools in Singapore with concrete, local models of innovation in teaching and learning strategies and in school administration using IT. Altogether there are 22 Phase I schools, comprising of 10 primary schools, 10 secondary schools and 2 junior colleges/centralised institutes (JC/CIs).

Phase II and III schools started their IT Masterplan implementation in 1998 and 1999 respectively. The identification of Phase II schools was based on the school principals' own evaluation of their staff readiness to embrace the new initiative. There are 106 Phase II schools while the remainder, 268 schools, are in Phase III. Schools within each phase are given the flexibility to decide on the pace of implementation.

As the priority of the Masterplan is to integrate IT into the curriculum, IT coaches from the Educational Technology Division (ETD) in the Ministry of Education (MOE) were sent out to schools to train teachers on the pedagogical principles to use IT effectively for teaching and learning purposes. Teachers were equipped with the knowledge and skills to integrate IT into their school curriculum through lesson demonstrations, modelling and hands on activities in the context of their own schools. Teachers were also trained in incorporating thinking skills and co-operative strategies in IT based lessons, so that they could provide pupils with opportunities to actively engage in higher order thinking. Apart from acquainting teachers with the pedagogies and methodologies of IT integration, teachers were trained in basic office application software, such as word processing and presentation tools, in an one off major training exercise from 1996-97.

Based on the implementation progress, it is an appropriate time to study the integration of IT in schools as the process of integration has reached a considerable level of maturity and stability for evaluation purposes (Lim, 2000). The main objective of this research project is to examine and analyse where and how IT is integrated in Singapore schools to engage pupils in higher order thinking. The project is funded by the Education Research Fund from MOE (Singapore). The specific objectives are:

1. To identify, describe and interpret the socio-cultural setting elements that promote or inhibit the successful integration of IT in Singapore schools.

2. To construct models of IT integration for Phase I, II, and III schools based on relationships and patterns identified.

The research study consists of two phases: Phase 1 is a questionnaire survey of Singapore schools to explore the critical aspects of IT integration among these schools; and Phase 2 is a collective case study of 10 schools that are chosen based on the degree of IT integration in Phase 1. This paper reports only the findings of Phase 1 (at the time of writing, the research team have only just started out on Phase 2 of the study). There are three main purposes for Phase 1:

1. It provides a descriptive and interpretive account of the critical aspects of IT integration among Singapore schools;

2. It formulates recommendations to facilitate the effective integration of IT in Singapore schools; and

3. It identifies the schools for the collective case study in Phase 2. Ten schools (five primary schools, three secondary schools, and two JC/CIs) will be chosen based on their degree of IT integration.

Design of the questionnaire

The effective use of questionnaires requires a clear understanding of the overall research context, to ensure that "the initial and concluding stages of the survey are not independent; the questionnaire structure must include all the facilities deemed to be necessary for successful analysis" (Youngman 1994, 248). The design of the questionnaire was guided by the following two criteria:

1. *Consistency with the literature on effective integration of IT in schools*. A review of the relevant literature identified elements considered important in integrating IT in schools. Some of these elements are:

    Integration Strategy: A school must have a clear vision of its IT integration strategies, and this vision must be shared by all members of the school community (Mize & Gibbons, 2000). That is, teachers need to know exactly how IT is to be used as a tool in the teaching and learning context. In their research study, Mize and Gibbons (2000) found that the most common comment made by teachers who did not have a clear vision of IT integration was that they did not have enough time to add the integration of IT on top of everything else that they were to teach daily.

    Leadership: It is important for school leaders to be role models in using IT. School leaders can lead the way by improving their own IT competencies through the attending at staff development with classroom teachers, using IT in their daily administration and communication tasks, and allowing teachers time to experiment with new teaching methods using IT (Mize & Gibbons, 2000).

Staff development: There is an urgent need for high level teacher training focusing on techniques and skills for integrating IT into the curriculum (Holmes, Savage & Tangney, 2000). In its report to the Council and the European Parliament, the EU Commission stated:

> Training teachers in the latest information technology is a continuing process, rather than a single event …principals reported that teachers' knowledge/skills in using computers for instructional purposes was a bigger problem than a perceived lack of interest (EU, 2000).

Researchers in the integration of IT also hold this belief in the continual training of teachers. According to Mize & Gibbons (2000), regular scheduled training opportunities keep teachers aware of the need to enhance their IT integration practices, as well as help them to keep up with the ever-changing face of IT. Parks and Pisapia (1994) suggest that teachers need formal training in the following areas: basic operation, integration of IT into existing lessons, integration of IT based instruction into the curricula, classroom management activities that allow use of IT during class time, peripherals, programming, selection, modification and evaluation of courseware, instructional and non-instructional uses of IT, matching of courseware with student abilities and learning styles, selection of hardware, development of user networks, and copyright protection issues.

Work environment: It is suggested that teachers in a stable work environment (low teacher turnover rate) are more receptive in the use of the IT tools (Mize & Gibbons, 2000). In their study of three public school classrooms, Mize & Gibbons (2000) discovered that teachers in less stable work environments tend to revert back to standard teaching strategies such as using standard textbooks and worksheet materials.

Facilities: According to Holmes and colleagues (2000), the current trend around the world is to improve the learner to computer ratio and to improve the quality of access to the Internet. The effort of putting technology into the hands of teachers is also being carried out in many countries. The British Educational Communications and Technology Agency (BECTA), in its 1998 report, stated:

> Research figures for the scheme (where selected IT-novice teachers were given their own portable computer) show a dramatic increase in the participant teachers' use of IT: over 90% successfully used CD-ROMs, 76% successfully used the Internet, and 95% used the portable at home and at school for planning and delivering their teaching (BECTA, 1998).

2. *Consistency with the IT Masterplan.*
   This includes the six domains that have been used by Singapore schools to plan, implement and evaluate their schools' IT programs:

teaching and learning (curriculum), resources, use of IT to promote admin and management excellence, and use of IT to promote learning beyond the classroom.

Based on these two criteria, the final version of the questionnaire developed by the research team consists of five categories: school IT culture, pupil use, teacher use, management of IT resources, and staff development (See Appendix 1). They enable us to study the degree of IT integration in the classrooms to promote higher order thinking skills within a wider context.

A more detailed description of the five categories is as follows:

1. *School IT culture*: This refers to six items - school IT policy, leaders' use of IT and their encouragement of staff use, collegial exchanges of knowledge and experiences with IT, encouragement given to experimentation and innovative use of IT, review of school IT programs, and involvement of staff in the review.

2. *Pupil use*: This includes the following five items - proficiency in the use of IT, types of learning with IT, promotion of higher order thinking mediated by IT, involvement in collaborative work mediated by IT, and type of learning in IT based collaborative work.

3. *Teacher use*: There are four items - proficiency in use of IT, integration of IT in classroom practices, use of IT to promote higher order thinking, and types of collaboration among teachers through the use of IT.

4. *Management of IT resources*: This includes two items - teachers' and pupils' access to IT resources, and monitoring of the use of IT resources to promote optimal use.

5. *Staff development*: This refers to two items - learning opportunities for IT integration, and review of staff development opportunities to meet professional needs.

A five-point scale is used as a rating scale for the responses of all items in the five categories. For example, under the item of school IT policy, the descriptions are 1 for "No school policy on the use of IT", 3 for "School policy in some areas that is adopted by some staff", and 5 for "Established and comprehensive school policy in many areas that is adopted by most staff". The descriptions are provided for the extreme points and middle point of the scale. This ensures a more elaborated scale, but at the same time, reduces the cognitive load on the respondents. The three-point description was applied to all items in the questionnaire: point 1 of the scale is associated with no or little integration of IT, point 3 is associated

with moderate integration of IT, and point 5 is associated with high integration of IT.

Implementation of the questionnaire

The questionnaire was first posted on a password protected website to provide schools easy access to the questionnaire (All schools in Singapore are Internet enabled). Such an implementation eliminated the burden on the part of the schools to manually mail back the completed questionnaire. Emails were sent to the schools in early May 2001 explaining the objectives and nature of the research project and requesting either the IT coordinator or head of department (HOD) IT to complete the questionnaire.

The IT coordinators or HOD (IT) were selected to be the respondents of the questionnaire as they were most likely to have the best understanding of the various issues of IT integration in their respective schools. To ensure data integrity, the research team went down to the schools of 30 respondents, selected randomly, to validate the responses in the questionnaire submitted. The research team members toured school facilities, studied school documentation of IT policies and issues, and spoke to teachers, pupils and school administrators. There were little discrepancies between the responses of these 30 HOD (IT) or IT coordinators and the observations of the research team members.

The initial response rate was very low and it might be due to the following reasons:

- HOD in some schools reported to us that their schools could not access the web based questionnaire. This could be due to some firewall problems that had blocked their access to our server.
- The email addresses of some schools (about 2.6%) were incorrect.
- The disk spaces of some schools' mailboxes were above quota.
- The implementation of the questionnaire coincided with the schools' mid-year examinations. As a result, many schools were too busy to respond to the questionnaire.

We rechecked the schools' email addresses and waited for a week before sending reminder emails to the schools, including emails to all principals informing them about the objectives of the questionnaire. We hoped that in the span of these two weeks, the disk spaces of some schools would be freed up. The number of respondents went up to 139. The team then decided to mail the questionnaire to all the remaining schools, along with a self addressed stamped envelope to facilitate the schools' return of their responses. After 3 reminders, the final tally went up to 328 responses.

Reliability of the questionnaire

A reliability test was carried out immediately after the data of the 328 questionnaires has been keyed into the SPSS package. In the context of this study, the reliability of the questionnaire is the extent to which the questionnaire provides the same results with repeated measurement. Evidence of an instrument's reliability is normally demonstrated with one or more of several generally accepted procedures (Hittleman & Simon, 1997). The procedure used in this study is the internal consistency reliability test.

Internal consistency reliability estimates how consistently individuals respond to the items within a scale. One of the widely used internal consistency reliability methods is the Cronbach's alpha. The alpha figures can range from 0 to 1. If there is no true score but only error in the items (which is esoteric and unique, and, therefore, uncorrelated across individuals), then the coefficient *alpha* will be equal to zero. If all items are perfectly reliable and measure the same thing (true score), then coefficient alpha is equal to 1. An instrument is generally deemed to be internally consistent if it has an alpha above .60 (DeVellis, 1991).

Table 1 shows the alpha reliability figures for each category of the Phase 1 questionnaire. The figures indicate that the items on the questionnaire are satisfactory in terms of their consistency in measuring each of the five categories. The alpha coefficient for the overall questionnaire is high at .90.

Table 1: Internal consistency (Cronbach Alpha Coefficient) N = 328

Category	Alpha reliability
Management of IT resources	.64
Pupil use	.80
Staff development	.64
School IT culture	.75
Teacher use	.76

Questionnaire findings

IT Phases

As mentioned earlier, the IT Masterplan was implemented in three phases, beginning in 1997. Table 2 shows the breakdown of respondents in terms of the IT phases.

Table 3 shows the mean (*M*), standard deviations (*SD*), minimum (Min) and maximum (Max) scores of each IT phase for the different categories.

Table 2: Frequency of response (IT phase)

Phase	Frequency	% of schools that responded
1	20	90.9
2	92	86.8
3	216	87.1

Table 3: Scores of the different IT phases

Category	Phase	*M*	*SD*	Min	Max
Management of IT resources	1	7.85	1.31	6	10
	2	7.54	1.47	5	10
	3	7.41	1.42	3	10
Pupil use	1	17.70	2.23	15	22
	2	16.32	2.84	9	25
	3	15.29	3.10	7	25
Staff development	1	7.45	1.43	6	10
	2	6.64	1.42	3	10
	3	6.38	1.35	2	10
School IT culture	1	24.30	3.10	18	30
	2	23.02	3.31	15	30
	3	22.16	3.35	12	30
Teacher use	1	13.40	2.33	8	18
	2	11.90	2.11	7	17
	3	11.58	1.96	6	20

To determine whether there are any significant differences among the three groups' means, we carried out an analysis of variance (ANOVA) on the IT phases. The analysis helps to draw conclusions about the degree of IT integration among schools in the three IT phases. The results of the ANOVA are presented in Table 4.

From Table 3, attention has to be drawn to the large differences in terms of the range of pupil use among Phase II and III schools as compared to among Phase I schools, and the high ranges for teacher use among the three phases of schools. Among Phase I schools, the pupil use scores varied from 15 to 22 (range = 7 out of a possible range of 24), whereas the ranges of pupil use scores amongst Phase II and III schools were more than twice as much at 16 and 18 respectively. That is, the degree of IT integration with respect to pupil use varies more widely among Phase II and III schools than among Phase I schools. Among the three phases, the ranges for teacher use scores were high at 10, 10 and 14 (out of a possible range of 16) for Phase I, II and III schools respectively.

The ANOVA revealed that there were significant differences among the three IT phases in the following categories:

- pupil use (F [2, 325] = 8.53, $p < .001$)
- staff development (F [2, 325] = 6.02, $p < .01$)
- school IT culture (F [2, 325] = 5.17, $p < .01$)
- teacher use (F [2, 325] = 7.63, $p < .001$)

Table 4: ANOVA of IT phases
** $p< .01$, *** $p< .001$

Category	SS	df	MS	F
Management of IT resources	4.23 661.52	2 325	2.11 2.04	1.04
Pupil use	151.49 2886.26	2 325	75.74 8.88	8.53***
Staff development	22.63 611.22	2 325	11.32 1.88	6.02**
School IT culture	114.15 3585.48	2 325	57.07 11.03	5.17**
Teacher use	62.61 1333.58	2 325	31.31 4.10	7.63***

Post hoc (Scheffe) tests comparing group means were used to identify which specific IT phases were responsible for the significant differences in each of the four categories. The results of the Scheffe tests are presented in Table 5.

Table 5: Scheffe tests of IT phases
* $p< .05$, ** $p< .01$, *** $p< .001$

Comparison	Mean Difference				
	Mgmt of IT	Pupil use	Staff dev	IT culture	Teacher use
Phase 1 Phase 2	.31	1.38	.81	1.28	1.50*
Phase 1 Phase 3	.44	2.41**	1.07**	2.14*	1.82***
Phase 2 Phase 3	.14	1.03*	.26	.86	.32

The following findings can be drawn from Table 5:

- Pupils in Phase I schools (mean = 17.70) were using IT in their learning significantly more than their counterparts in Phase III schools (mean = 15.29, $p < .01$). Similarly, pupils in Phase II schools (mean = 16.32) were also using IT in their learning significantly more than their counterparts in Phase III schools (mean = 15.29, $p < 0.05$).

- In terms of staff development, teachers in Phase I schools (mean = 7.45) had a significantly greater opportunity for professional development in the integration of IT in schools than Phase III schools (mean = 6.38, $p <$ .01).

- There was a significantly more conducive IT culture in Phase I schools (mean = 24.30) than Phase III schools (mean = 22.16, $p <$ .05).

- Teachers in Phase I schools (mean = 13.40) used IT in their teaching significantly more than their counterparts in Phase II (mean = 11.90, $p <$ .05) and Phase III (mean = 11.58, $p <$ .001) schools. However, there was no significant difference between Phase II and III schools in terms of teacher use.

- No significant difference was found among any of the IT phases in terms of management of IT resources.

Levels of school

Out of the 328 schools that responded, 168 were primary schools, 144 secondary schools and 16 JC/CIs. As shown in Table 6, these represented 86.6%, 87.3% and 94.1% of all the total primary schools, secondary schools and JC/CIs respectively.

Table 6: Frequency of response (school level)

Schools	Frequency	% of schools that responded
Primary	168	86.6
Secondary	144	87.3
JC/Centralised Inst.	16	94.1

Table 7 shows the mean (*M*), standard deviations (*SD*), minimum (Min) and maximum (Max) scores of the three levels of school in each of the five different categories. The ranges of scores for all categories of IT integration among JC/CIs were the lowest. The lower variation in scores among JC/CIs may be due to their low number, as compared to Primary and Secondary schools.

To determine whether there are any significant differences among the three groups' means, we carried out an ANOVA on the levels of school. The results of the ANOVA are presented in Table 8. The ANOVA results revealed that there were no significant differences among the Primary, Secondary and JC/CIs schools in terms of management of IT resources, pupil use, staff development, school IT culture and teacher use.

Table 7: Scores of the different levels of school

Category	Level	*M*	*SD*	Min	Max
Management of IT resources	Primary	7.54	1.37	3	10
	Secondary	7.41	1.50	4	10
	JC	7.31	1.40	5	10
Pupil use	Primary	15.43	3.10	7	25
	Secondary	15.92	3.01	7	24
	JC	17.06	2.43	15	25
Staff development	Primary	6.52	1.36	2	10
	Secondary	6.48	1.39	3	10
	JC	6.88	1.71	4	10
School IT culture	Primary	22.77	3.10	14	30
	Secondary	22.19	3.65	12	30
	JC	23.19	3.19	17	28
Teacher use	Primary	11.66	2.09	6	20
	Secondary	11.89	2.05	6	17
	JC	12.06	2.05	9	16

Table 8: ANOVA of levels of school

Category	SS	df	MS	F
Management of IT resources	1.78 663.97	2 325	.89 2.04	.44
Pupil use	48.67 2989.08	2 325	24.34 9.20	2.65
Staff development	2.26 631.59	2 325	1.13 1.94	.58
School IT culture	33.31 3666.32	2 325	16.65 11.28	1.48
Teacher use	5.38 1390.82	2 325	2.69 4.28	.63

Types of school

Table 9 shows the breakdown of these schools into six different types: independent, government autonomous, government aided, government aided autonomous, government and full school. Full schools function with both Primary and Secondary sections. As all schools are expected to reach the national standards of IT provision eventually, the MOE extends full grant financing to all schools, including the independent, autonomous and government aided schools.

Independent, government autonomous, and government aided autonomous schools share the following common characteristics:

1. They have greater autonomy and flexibility to introduce innovations and educational programs to challenge their pupils.

2. They receive additional funding from the Ministry of Education for school development and maintenance.

Table 9: Frequency of response (six school types)

School Type	Frequency	% of schools that responded
Independent	7	87.5
Government autonomous	12	92.3
Government aided	61	77.2
Government aided autonomous	4	57.1
Government	241	83.4
Full school	3	100

As the number of schools in the independent, government autonomous and government aided- autonomous types is small, and they share the above mentioned characteristics, they are grouped into one category in this study and named "Independent auto". Government-aided schools are classified separately from government schools because the former are managed by boards of governors, usually from clans or religious organisations, empowered to recruit staff of their own. Table 10 shows the three new categories of schools used in our analyses.

Table 10: Frequency of response (three school types)

Schools	Frequency
Ind-auto (independent-autonomous)	26
Gov-aid (government-aided)	61
Gov (government)	241

The mean scores (*M*), standard deviations (*SD*), minimum (Min) and maximum (Max) of the different types of school are presented in Table 11. The ANOVA test was conducted to determine whether there was any significant difference among the means of the independent autonomous, government aided, and government schools. The results of the ANOVA on the different schools are presented in Table 12.

The ANOVA revealed that there were significant differences among the means of the three types of school in the following categories:

- management of IT resources (F [2, 325] = 3.65, $p < .05$)
- pupil use (F [2, 325] = 7.96, $p < .001$)
- staff development (F [2, 325] = 6.31, $p < .01$)

- school IT culture (F [2, 325] = 5.08, $p < .01$)
- teacher use (F [2, 325] = 4.02, $p < .05$)

Table 11: Scores of the different types of school

Category	School type	*M*	*SD*	Min	Max
Management of IT resources	Ind auto	8.19	1.58	5	10
	Gov aid	7.41	1.44	4	10
	Gov	7.41	1.39	3	10
Pupil use	Ind auto	17.96	2.76	12	24
	Gov aid	15.46	3.64	7	25
	Gov	15.55	2.82	7	23
Staff development	Ind auto	7.42	1.65	5	10
	Gov aid	6.54	1.40	4	10
	Gov	6.42	1.33	2	10
School IT culture	Ind auto	24.46	3.71	18	30
	Gov aid	22.67	3.45	14	30
	Gov	22.29	3.25	12	30
Teacher use	Ind auto	12.85	2.48	8	17
	Gov aid	11.54	2.44	6	20
	Gov	11.73	1.88	6	17

Table 12: ANOVA of types of school
* $p< .05$, ** $p< .01$, *** $p< .001$

Category	SS	df	MS	F
Management of IT resources	14.63	2	7.31	3.65*
	651.12	325	2.00	
Pupil use	141.94	2	70.97	7.96***
	2895.81	325	8.91	
Staff development	23.68	2	11.84	6.31**
	610.67	325	1.88	
School IT culture	112.06	2	56.03	5.08**
	3587.57	325	11.04	
Teacher use	33.74	2	16.87	4.02*
	1362.46	325	4.19	

Scheffe's tests were then used to identify which schools' means are different from each other. The results of Scheffe's tests are presented in Table 13.

The following findings can be drawn from Table 13.

1. There was significantly better management of IT resources in independent autonomous schools (mean = 8.19) than government schools (mean = 7.41, $p < .05$).

Table 13: Scheffe tests of types of school
* $p< .05$, ** $p< .01$, *** $p< .001$

Comparison	Mean Difference				
	Mgmt of IT	Pupil use	Staff dev	IT culture	Teacher use
Ind auto Gov aid	.78	2.50**	.88*	1.79	1.31*
Ind auto Gov	.78*	2.41***	1.00**	2.17**	1.12*
Gov aid Gov			.12	.38	.19

2. Pupils in independent autonomous schools (mean = 17.96) were using IT in their learning significantly more than their counterparts in government aided schools (mean = 15.46, $p < .01$) and government schools (mean = 15.55, $p < .001$).

3. In terms of staff development, teachers in independent autonomous schools (mean = 7.42) had a significantly greater opportunity for professional development in IT integration than those in government aided (mean = 6.54, $p < .05$) and government schools (mean = 6.42, $p < .01$).

4. The IT culture in independent autonomous schools was significantly more conducive (mean = 24.46) than that in government schools (mean = 22.29, $p < .01$).

5. Teachers in independent autonomous schools (mean = 12.85) used IT in their teaching significantly more than their counterparts in government aided (mean = 11.54, $p < .05$) and government (mean = 11.73, $p < .05$) schools.

6. No significant differences were found between government aided and government schools in any of the five categories.

Correlations among the categories of the Phase 1 questionnaire

We are also interested in knowing whether there are any systematic relationships among the five categories: management of IT resources, pupil use, staff development, school IT culture and teacher use. To do this, the Pearson product moment correlation test was used. Results are shown in Table 14.

The following findings can be drawn from Table 14:

Table 14: Correlation among the five categories
** $p < .01$

	Manage-ment	Pupil use	Staff devt	IT culture	Teacher use
Management of IT	1.00	.426**	.484**	.581**	.406**
Pupil use			.588**	.557**	.617**
Staff dev				.567**	.520**
IT culture					.573**
Teacher use					1.00

1. The relationships between management of IT resources and pupil use, staff development, school IT culture, teacher use are positive and significant ($p < .01$). This means that better management of IT resources relates to higher pupil use, greater staff development opportunities, more conducive school IT culture and more teacher use of IT.

2. The relationships between pupil use and staff development, school IT culture, teacher use are also positive and significant ($p < .01$). This means that higher pupil use is related to greater staff development opportunities, more conducive school IT culture and more teacher use of IT.

3. Staff development is positively and significantly correlated with the school IT culture and teacher ($p < .01$). Greater staff development opportunities relates to more conducive school IT culture and more teacher use of IT.

4. Finally, there is positive and significant relationship between the school IT culture and teacher use ($p < .01$). This means that the more conducive the school IT culture is, the greater is the teachers' use of IT.

Conclusion and recommendations

From the findings presented in the previous section, we are able to formulate the following recommendations that will facilitate the effective integration of IT in Singapore schools.

Construction of IT integration models for Singapore schools

There is an urgent need for models of effective IT integration in Singapore schools. Although the significant differences in pupil and teacher use of IT, staff development of teachers, and IT culture between the Phase I and III schools may imply a need for greater focus on Phase III schools, one has to take into account the fact that Phase I schools have three years head start from Phase III schools. Moreover, Phase I schools are selected by the MOE

based on their records in IT integration, and Phase II schools are a self selected group based on school management's evaluation of staff readiness for the IT Masterplan. What is interesting about this finding is that there is no significant difference in the scores of the management of IT resources among the three different phases. This may suggest that the principles for management of IT resources formulated by Phase I schools are more easily adopted by Phase II and III schools to facilitate IT integration, as compared to the principles for pupil use, staff development, school IT culture and teacher use.

A more in depth analysis of the significance level among the different phases shows that pupil use and teacher use have the highest significance difference. There is also a large variation in pupil use among Phase II and III schools as compared to among Phase I schools. All these suggest the need to document the effective integration of IT at the classroom level, to tease out principles for pupil and teacher use of IT for learning and teaching. However, we have to be aware that the correlations among the management of IT resources, pupil use of IT, teacher use of IT, staff development and IT culture are significant and highly positive. That is, the principles that are formulated in one category are interdependent with those in another category.

Addressing an area of IT integration without considering the other areas may have detrimental effects on schools (Lim, 2001). The activity theoretical framework (Engeström, 1993) that has been adopted by Phase 2 of the study provides such a holistic approach towards the construction of IT integration models for schools. Cases studies that document and analyse the effective IT integration processes in schools of various phases will facilitate the construction of such models.

Phase 2 of the main study (in progress) aims to construct these IT integration models that are easily customisable to the context of each school. To gather accounts of different realities that have been constructed by various groups and individuals in the learning environment, both qualitative and quantitative methods are drawn upon in Phase 2: observations of IT and non-IT based lessons, face to face interviews with principals and IT coordinators, focus group interviews with pupils and teachers, questionnaires for teachers and students, and samples of pupils' work.

Developing strategies for pupil it competency development in selected government and government aided schools

Based on the findings of the study, pupils in independent autonomous schools are using IT in their learning significantly more than their counterparts in government aided and government schools. The

significance level was especially high between independent autonomous and government schools ($p < .001$), and high among independent autonomous and government aided schools ($p < .01$). Although the teacher use of IT has a significant and positive effect on the pupil use, the significant differences for independent autonomous and government schools, and independent autonomous and government aided schools are relatively lower ($p < .05$).

In these government and government aided schools, other factors such as type of pupils, socio-economic background of pupils, and strategies for pupil IT competency development may affect pupil use (Lim, 2000). New strategies for pupil IT competency have to be explored in selected government and government aided schools to improve upon their low pupil use. Such strategies may include just in time learning where IT skills are being taught just before the skills are applied within the context of a discipline, or an inter-disciplinary project work.

Setting IT competency standards for teachers and pupils

IT not only mediates lifelong learning in schools, but also extends learning beyond formal classroom settings and provides practice with self directed investigations as individuals move into internships, first professional positions, and increasing responsibilities in all arenas of life. Therefore, IT competency among teachers and pupils is not only a mediating element; it is also a desired outcome of effective IT integration. Given the high ranges of both the teacher use and pupil use among the different phases of schools in the self reporting questionnaire, there is a need to set IT competency standards for teachers and pupils. The standards set may be in both technical and pedagogical IT competencies that are customisable to the context of each school. The application of such standards will allow teachers and pupils to seamlessly integrate learning materials from a wide range of sources. This promotes the development of learning environments that are tailored to the individual needs of pupils (Owen, 1999).

This paper has explored the critical aspects of IT integration, school IT culture, pupil use, teacher use, management of IT resources and staff development, among Singapore schools. The questionnaire survey findings include: (1) Phase I schools in the IT Masterplan have significantly higher pupil and teacher use of IT, greater opportunities for staff development, and more conducive IT culture than Phase III schools; (2) Independent autonomous schools have significantly higher teacher and pupil use of IT for teaching and learning than government and government aided schools; and (3) The correlations among the

management of IT resources, pupils use of IT, teacher use of IT, staff development and school IT culture are significant and highly positive.

Based on these findings, the authors recommend the construction of IT integration models for Singapore schools, the development of strategies for pupil IT competency development in selected government and government aided schools, and the setting of IT competency standards for teachers and pupils in Singapore schools. These recommendations may then be addressed as the research team completes Phase 2 of the study in the 10 schools that it has identified for case studies of effective IT integration.

Acknowledgements

References

BECTA (1998). *How learning is changing: information and communications technology across Europe - ICT in education policy*. London: BECTA Publication. [verified 24 Oct 2002] http://www.eenet.org/cgi-bin/view/medien/view_medien.pl?datensatz=medzl5WTT8V2QXdNojDGOIaab4AEU6 KsHP1ffpFHHODC6boZbfK8e1034263379

DeVellis, R.F. (1991). *Scale Development: Theory and Applications*. Newbury Park: Sage Publications.

Engeström, R. (1993). Development studies on work as a testbench of activity theory. In S. Chaiklin & J. Lave (Eds), *Understanding Practice: Perspectives on Activity and Context*. New York: Cambridge University Press, 53-72.

European Union (2000). *Designing Tomorrow's Education Promoting Innovation with New Technologies*. Brussels, Report of the EU Commission Report to the Council and the European Parliament. [verified 24 oct 2002] http://europa.eu.int/comm/education/elearning/rapen.pdf

Hittleman, D. R., & Simon, A. J. (1997). *Interpreting Educational Research. An introduction for consumers of research*. 3rd Edition. Pearson Education Inc, Upper Saddle River, NJ.

Holmes, B., Savage, T., & Tangney, B. (2000). *Innovation in Learning in the Information Society: A Comparative International Study*. Report to the Lifelong Learning Group of the Information Society Commission. Dublin: The Centre for Research in IT in Education. [verified 24 Oct 2002] http://odtl.dcu.ie/mirror/crite/CRITEfinal.html

Lim, C. P. (2000). *Situating Information and Communication Technologies in the Economics Course*. Unpublished PhD dissertation. University of Bristol.

Lim, C.P. (2001). A holistic approach towards the use of an integrated online delivery and management system. *Journal of Educational Media*, 26(1), 19-33.

Lim, C.P. (In press). E-learning in schools: Some lessons from pole-vaulting. *International Journal of Educational Technology*, 3(1). [journal contents at http://smi.curtin.edu.au/ijet/issues.html]

Ministry of Education (1997). *IT in Education*. Ministry of Education. [viewed 18 Dec 2001, verified 24 Oct 2002] http://www1.moe.edu.sg/iteducation/masterplan/summary.htm

Mize, C.D. and Gibbons A. (2000). *More than Inventory: Effective Integration of Instructional Technology to support Student Learning in K-12 Schools*. (ERIC Document Reproduction Service No. ED 444563)

Owen, M. (1999). Appropriate and appropriated technology: Technological literacy and educational software standards. *Educational Technology & Society*, 2(4). [verified 24 Oct 2002] http://ifets.massey.ac.nz/periodical/vol_4_99/martin_owen.html

Parks, A., & Pisapia, J. (1994). *Developing Exemplary Technology-Using Teachers. Research Brief #8*. (ERIC Document Reproduction Service No. ED 411360)

Salomon, G. (1993). No distribution without individuals' cognition. In G. Salomon (Ed), *Distributed Cognitions: Psychological and Educational Considerations*. New York: Cambridge University Press, 111-138.

Youngman, M.B. (1994). Designing and using questionnaires. In N. Bennett, R. Glatter & R. Levacic (Eds), *Improving Educational Management through Research and Consultancy*. London: The Open University, 248-266.

Appendix 1: Phase 1 Questionnaire

**Effective Integration of IT in Singapore Schools:
Pedagogical and Policy Implications**

This questionnaire is to be completed by the HOD(IT), IT coordinator, or any IT committee member.

Name of School:

For questions 1 – 19, choose from the scale of 1 to 5 the position that is most appropriate to the IT situation in your school.

School IT Culture

1. To what extent is the school policy on the use of IT adopted by the staff?

1	2	3	4	5
No school policy on the use of IT.		School policy in some areas that is adopted by some staff.		Established & comprehensive school policy in many areas that is adopted by most staff.

2. To what extent do the school leaders (principals, HODs, level heads) encourage the use of IT among staff?

1	2	3	4	5
Leaders do not adopt IT and do not encourage staff to use IT.		Leaders do not adopt IT but encourage staff to use IT.		Leaders serve as role models for effective use of IT and encourage staff to use IT.

3. To what extent is there collegial exchange of knowledge and experiences with IT?

1	2	3	4	5
No or little collegial exchange of knowledge & experiences with IT.		Collegial exchange occurs occasionally but is limited to those involved in IT-based projects.		Collegial exchange is widespread and ongoing among most staff.

4. To what extent is encouragement given to staff to experiment and be innovative in the use of IT?

1	2	3	4	5
Little, if any, encouragement is given.		Only staff members who are involved in formal projects are encouraged to experiment with and be innovative in the use of IT.		Both formal and informal experimentation and innovation with IT is valued as a learning experience, and is encouraged.

5. How is the school IT programme reviewed continually?

1	2	3	4	5
Review of the School IT Programme, if any, is done on an ad hoc basis.		Some form of system to review the programme continually.		Systematic and continual data-based review of the programme.

6. To what extent is the staff involved in the review of the school IT programme?

1	2	3	4	5
Only the leaders are involved in the review.		Some members of staff (other than the leaders) are involved in the review.		Most members of staff are involved in the review.

Pupil use

7. To what extent are pupils proficient in the use of IT?

1	2	3	4	5
Demonstrate basic competency in the use of IT.		Demonstrate the ability to select and use appropriate IT tools.		Demonstrate the ability to select and use appropriate IT tools creatively and are able to transfer their knowledge of the use of one IT tool to another.

8. How do pupils use IT for learning?

1	2	3	4	5
Use mainly for mastery learning.		Use to source for information, to facilitate analysis, synthesis and presentation of information.		Use to promote authentic learning tasks, to facilitate problem solving and interdisciplinary usage, and to evaluate pupils' own learning.

9. To what extent does the use of IT promote higher order thinking?

1	2	3	4	5
IT-based activities do not promote higher order thinking.		Some IT-based activities promote higher order thinking.		Most IT-based activities promote higher order thinking.

10. How often is IT used as a means of collaboration for learning purposes?

1	2	3	4	5
IT is not used.		IT is occasionally used.		IT is frequently used.

11. What kind of learning takes place during collaboration through the use of IT?

1	2	3	4	5
Mainly exchange of information.		Exchange of ideas, expertise, skills and resources.		Creation of knowledge, problem solving and/or decision making.

Teacher use

12. To what extent are teachers proficient in the use of IT?

1	2	3	4	5
Demonstrate basic competency in the use of IT.		Demonstrate the ability to select and use appropriate IT tools and resources.		Demonstrate proficiency in selecting and using a variety of IT tools and resources creatively and are able to transfer their knowledge of the use of one IT tool to another.

13. How do teachers integrate IT in their classroom practices?

1	2	3	4	5
Mainly drill-and-practice for mastery learning.		Select and use appropriate IT tools and instructional strategies to encourage independent learning.		Integrate IT seamlessly and creatively in their classroom practices that promote higher order thinking skills.

14. To what extent do teachers use IT to promote higher order thinking?

1	2	3	4	5
No activity involving the use of IT to promote higher order thinking.		Some activities involving the use of IT to promote higher order thinking.		Most activities involving the use of IT to promote higher order thinking.

15. What kinds of collaboration take place among teachers through the use of IT?

1	2	3	4	5
Passive exchange of existing information and teaching strategies.		Design and production of new resources or activities.		Collaboration is prevalent and results in the development of best practices.

Management of IT resources

16. To what extent do teachers and pupils have access to IT resources?

1	2	3	4	5
Teachers and pupils are not informed about the IT resources.		Teachers and pupils have some information of the IT resources.		Teachers and pupils are well-informed of the IT resources available and they know how to access the resources.

17. To what extent does the school monitor the usage of IT resources to promote optimal use?

1	2	3	4	5
The usage of IT resources is not monitored.		The usage of IT resources is monitored systematically.		The usage is monitored, staff provide feedback and follow-up actions to improve the usage.

Staff Development

18. How much opportunities are there for staff to develop their skills in supporting the integration of IT in your school?

1	2	3	4	5
Few IT-based staff development activities are organised.		Some IT-based staff development activities are organised.		An extensive and ongoing IT-based staff development plan exists. Many members of the staff contribute to staff development activities.

19. How are the staff development opportunities in supporting the integration of IT reviewed?

1	2	3	4	5
There is no review check.		There is frequent and informal review.		There is a system in place to ensure that staff development opportunities meet the professional needs.

Thank you very much for completing the questionnaire ☺

Contact person: Lim Cher Ping
Assistant Professor, Instructional Science Academic Group
National Institute of Education, Nanyang Technological University
1 Nanyang Walk, Singapore 637616, Republic of Singapore
Email: cplim@nie.edu.sg Fax: +65 399 4057 Tel: +65 790 3279