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ENGLISH LANGUAGE LEARNING IN A ONE-TO-ONE COMPUTING ENVIRONMENT – IMPACTS AND CONSIDERATIONS

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This case study research describes and evaluates the impacts of the learning of English language in an ICT-enriched learning environment, in a primary school under the FutureSchools@Singapore programme. Students from the school are provided with a ratio of one computing device to two students in Primary 1 and subsequently a one-to-one computing learning environment from Primary 2 (i.e. Grade 2) onwards. From Primary 4 onwards, students procure and use their own computing devices. This case study describes how ICT has been used for the teaching and learning of English. The frequency of ICT use in the English classrooms is presented. More importantly, the impacts in terms of the students' ICT skills, English test score and feedback from students involved are also presented and discussed. The students performed well in the ICT skill test. The students also performed relatively well in the English test as compared to a comparable school. In the English test, the ICT-enabled school reported a statistically significant higher mean score than the comparable school; the mean scores were 73.87 and 67.38 between the school and the comparable school, respectively. In general, the students commented that they were satisfied with the use of their notebook computers. They found it interesting, useful and easy to use. However, students complained about computer viruses, small computer screen, battery lifespan, weight of their notebook computers, slow Internet connect speed and Internet connection errors. In the self-reported higher-order thinking questionnaire, no significant difference was found for students' problem-solving and reflective thinking skills between the school in this study and the comparable school.

Keywords: One-to-one computing; impacts; evaluation; future schools.

1. Introduction

1.1. *Objectives*

The main intent of this research study is to obtain a more in-depth understanding of the impact of the use of Information Communication Technology (ICT) in the teaching of English in a primary school under the FutureSchools@Singapore program. This paper also describes how ICT has been used for the teaching and learning of English.

1.2. *Background*

The school in this case study research, is the first primary level future school that was set up under the FutureSchools@Singapore program in 2008. It is situated in a typical working class neighbourhood in the western part of Singapore. The school's core mission is to seek innovative teaching approaches that leverage on technologies to better engage the new generation of young learners. The school has implemented a successful one-to-one program (i.e. one-to-one computer to student ratio) for all its students. The program ensures a two-to-one student-to-computer ratio for its Primary 1 students and a one-to-one student-to-computer ratio for Primary 2 and 3. The computer ownership program, where students procure and own their own notebook computers, has been introduced to all Primary 4 students. In other words, students are to procure their own personal notebook computer for use in school everyday and at home for the purpose of learning. The program promotes the vision for every child to own a personal learning device to support, extend and enrich their learning. A student-owned model is adopted to ensure sustainability of the one-to-one program.

2. Literature Review

Review of existing literature regarding the impacts of ICT use in education settings (Binnur, 2009; Brescia, Kissinger, & Lee, 2009; Kim & Jung, 2010; Krish, 2008; Softa, 2011; Suhr, Hernandez, Grimes, & Warschauer, 2010) has presented preliminary evidence that ICT use is possibly positively correlated to academic performance. The acquisition of higher-order related type of thinking skills (e.g. problem-solving and critical thinking skills) (Lim & Tay, 2003; Takahira, Ando, & Sakamoto, 2007) has also been reported. A limitation of this review is that the majority of the studies reviewed examines the impact of ICT on English language achievement, specifically in the context of English being studied as a foreign, non-native language. Also, the studies are not specifically targeted at the elementary school context. Nonetheless, the findings and insights presented are still of valuable consideration. Research studies generally indicate positive impacts of ICT use in educational settings, specifically in terms of academic achievement in the study of English language. On the other hand, they also caution the possible drawbacks, issues and considerations of ICT use as well.

2.1. *Positive impacts of ICT use in educational settings*

Positive impacts reflected are – positive levels of learning engagement and motivation, higher test scores and the acquisition of higher-order thinking skills.

2.1.1. *Positive levels of learning engagement and motivation*

ICT is beneficial in terms of fostering a positive learner attitude and level of engagement, which is especially crucial in the context of the learning of a foreign language where motivation can be difficult to foster and harness. Softa (2011), a study partly investigating the impact of an ICT-enriched environment on the learning of English as a foreign language, reports that "students reflected a more positive attitude and a feeling of relief while performing in a technologically advanced environment, like not getting emotional or anxious when expressing in English or making a question in English to the teacher". Binnur (2009) studying the effect of technology on motivation in English Foreign Language (EFL) classrooms, reports that technology is a dynamic and challenging, motivating factor in EFL classrooms.

2.1.2. *Higher test scores*

Research studies suggest that ICT usage is positively correlated with higher test scores. Brescia et al. (2009) carried out an analysis on a nationally representative sample of 7,196 high school sophomore students, generated from the databases of the *Educational Longitudinal Study* by Washington, DC: National Center for Education Statistics, and its three predecessor studies, to examine the influence of the amount of after-school computer use (independent variable) on academic achievement level (dependent variable). Four control variables were identified in this study - socioeconomic status (SES), home computer access, parental involvement, and academic expectation. They were controlled via the cross-referencing of a multilevel database that provides insight into the students' background, school environment and their influences on the student. The findings indicated that academic achievement, specifically in math and reading test scores - appears to be influenced by the amount of computer use - even when controlling the effects of possible factors that impact students' academic achievement. The results reflected that students who used the computer for one hour per day for both schoolwork and non-schoolwork purposes had significantly better reading and math test scores and more positive English and math teacher evaluations for their classroom behaviours than any other groups. They concluded that the after-school use of computers, albeit insufficiency in ensuring students' academic success, can be a powerful tool in doing so. This study provides reason for the recommendation to parents and teachers that students should use the computer regularly, perhaps an hour daily as found by the study to have a significant impact on students' academic achievement, regardless of a student's background and environmental conditions.

2.1.3. *Acquisition of higher-order thinking skills*

Passey (2000) explored how ICT could be used to facilitate the various types of learning outcomes (e.g. from basic knowledge acquisition to higher type of thinking skills, such as, evaluation) with ICT. Passey (2000) discussed the Bloom's (1952) Taxonomy, De Bono's Thinking Hats (1985) and Gardner's (1991) learning approaches in relation to learning with ICT.

Lim and Tay (2003) also discussed higher-order thinking with regard to the use of ICT. They mentioned Gagne, Briggs, and Wager's (1992) five categories of learning outcomes (i.e. verbal information, intellectual skills, cognitive strategies, attitudes and motor skills). Intellectual skills are further subdivided into five hierarchically ordered subcategories and they are: (a) discriminations; (b) concrete concepts; (c) defined concepts; (d) rules; and (e) higher-order rules – problem-solving. Lim and Tay (2003) also mentioned Young's (1997) and the Iowa Department of Education's (1989) definition of higher-order thinking. Young (1997) suggested that higher-order thinking is more than the simple recall of facts or information retrieval. It is a function of interaction between cognitive strategies, meta-cognition, and nonstrategic (domain-specific) knowledge during novel problem-solving. According to the Iowa Department of Education (1989, p. 7), higher-order thinking skills are then "goal directed, multi-step, strategic processes such as designing, decision making, and problem solving" that require analysing, evaluating, connecting, imagining, elaborating and synthesising. Both Passey (2000) and Lim and Tay (2003) focused on how ICT could be used to facilitate the acquisition of higher-order thinking among students (see mentioned manuscripts for more details).

The above discussion seems to suggest that the concept of higher-order thinking is varied. For this research study, we focus on two possible aspects of the higher-order type of thinking (i.e. problem-solving and self-reflective thinking of the students).

2.2. *Issues with the use of ICT in educational settings*

While much has been said about the positive impacts of ICT use for teaching and learning, concerns were also raised alongside. Some of the authors who have reported the positive impacts have also raised concerns (Krish, 2008; Lai & Pratt, 2007; Mouri, Sakamoto, Hatano, & Sakamoto, 2002; Suhr et al., 2010). These authors have reported insignificant impacts on students' English test scores (Tilfarlioğlu, 2011; Tse, Yuen, Loh, Lam, & Ng, 2010) and ICT as a distractor besides adding to the complexity to students' learning (Blumenfeld, Kempler, & Krajcik, 2006; Krish, 2008; Lai & Pratt, 2007; Suhr et al., 2010).

The use of ICT alone as a motivating factor is insufficient in ensuring academic achievement (i.e. good test scores) as it is not equivalent to the presence of cognitive engagement and the latter mediates the ways in which values and needs relate to learning and achievement (Blumenfeld et al., 2006). The presence of opportunities does not indicate that users naturally reap the benefits of these opportunities. This view is cohered

by Binnur (2009) that while technology can motivate learners, teachers should not be fully reliant on the usage of technology as the panacea for positive motivation, cognitive engagement and good test scores; the lessons should be based on well-designed technological classrooms and pedagogical considerations. This is further cohered by Lim and Tay's (2003) view that ICT tools play a neutral role and it is more important to consider how the tools are being utilised than what types of tools are being used.

Tay, Lim, and Lim (2013) also highlighted the possible technological and infrastructural complexities in the introduction and use of ICT pervasively in the school setting. For instance, additional funding would be necessary to set up the computer network, procurement of the computing equipment and manpower for maintenance of the technological infrastructure and equipment.

2.3. *Challenges in measuring actual impact of an ICT-enriched environment*

Current modes of standardised pen-and-paper tests are an instrument employed to measure a student's level of academic achievement, it basically assesses basic skills through fixed-response questions. Therefore, it is limited in its ability to reflect the cognitive changes in student learning that may occur when ICT usage is increased. As fixed-response based questions are often limited to factual questions or simple applications; which allow for learners to solely leverage on low-level learning strategies and cognitive skills such as the memorisation of information and the regurgitation of keywords, while being cognitively disengaged (Blumenfeld et al., 2006).

This observation points us to two areas worthy of further discussion – instruments to measure cognitive engagement of learners and reconsidering the status quo of the education system that is primarily geared towards performance.

For the former, suggestions of other instruments are portfolios, evaluations and interviews with teachers and students for a comprehensive assessment of student achievement. Suhr et al. (2010) mentioned that more authentic forms of literacy assessment, such as those involving performance and portfolios, are not yet standardised, nor do they have much weight in educational policy and administration decisions. Such assessments are also expensive to carry out.

For the latter, it is important to consider the matchability between ICT and the current status quo of the education system, if they do indeed complement and align with each other, aiding in achieving desired outcomes.

2.4. *ICT in education - Striking a balance*

The above literature review seems to suggest that ICT in educational settings could bring about higher level engagement and motivation among learners, improve English test scores and also facilitate the learning of higher-order type of thinking skills. However, there are also research studies that report insignificant impact on students' test scores. It has also pointed out that, the use of ICT requires extensive effort and additional support in terms of infrastructures and resources. Instead of a tool for engagement, the use of ICT could also be a device that distracts the students from their academic or learning tasks.

3. Research Design and Methods

A case study approach is used in this research study to look into the impacts and considerations of the ubiquitous use of ICT in the teaching and learning of English in a primary school context, focusing on the pioneer batch of Primary 4 students who has been with the school since its inception from January 2008. The school in this case study is one of the three primary level future schools under the FutureSchools@Singapore project by the Ministry of Education and Infocomm Development Authority of Singapore. It is also funded by the National Research Foundation, Singapore.

The main research question for this research study is to look into the impacts and considerations of the use of ICT (e.g. computers) in primary school students' learning of the English language as the first language. The whole cohort of 225 Primary 4 students and five teachers who were teaching them English were involved in this case study research in 2011. The research study also attempts to provide a more holistic understanding of the impacts and considerations from the multiple points of data from the students (i.e. their English test scores, ICT skill levels, self-reported survey on their problem-solving and self-reflective thinking skills, ICT usage rate and feedback), the teachers (i.e. interviews) and the artefacts (i.e. document review). Multiple data points, as described below and in Table 1, were collected to provide a more holistic understanding of the possible impacts and considerations for the learning of the English language in a one-to-one computing environment.

The following data were being collected for analysis and triangulation – (1) interview with the five English teachers who taught the pioneer batch of Primary 4 students; (2) the students' frequency of in class ICT use survey; (3) feedback from the 167 Primary 4 students; (4) document review of scheme of work, lesson plans and reports written; (5) the students' English test scores in comparison with another primary school with slightly higher socioeconomic status; (6) the students' ICT skills test scores and (7) the students' self-reported questionnaire survey on higher-order type of thinking skills (i.e. problem-solving and reflective thinking) as compared to a comparable school. Table 1 is a summary of the research methods, data sources, and analysis of data.

The various research methods seek to explore in greater depth the impact of ICT use through the literature review above. The interview with the teachers, the students' feedback and the frequency of ICT use could establish the students' level of engagement/motivation in class and also whether ICT distracts students' from their academic/learning tasks. The comparison of English test scores against the comparable school could provide further insights on the relationship and significance between ICT use and English test performance. The interview with the teachers and the student self-reported questionnaire would provide further understanding towards whether ICT could be used to facilitate the acquisition of higher-order type of learning. The interview with the teachers and review of related school documents (i.e. reports and papers written by teachers) provides details into the one-to-one implementation process (e.g. the extra efforts required by the staff, more manpower and additional technological infrastructures).

Table 1. Summary of research methods, data sources and analysis of data.

No.	Research Methods	Data Sources	Analysis of Data
1.	▪ Document review	▪ Scheme of work ▪ Lesson plans ▪ Reports and papers written	▪ Formal records of scheme of work and lesson plans ▪ Implementation of the one-to-one requirements and insights
2.	▪ Interviews and dialogue with 5 English teachers	▪ Transcripts of interviews	▪ Coding of data on how ICT had been used for teaching and learning ▪ Students' levels of engagement ▪ Students' learning of higher-order type of thinking skills ▪ Insights into the one-to-one implementation process
3.	▪ Primary 4 students' frequency of ICT use in class	▪ Students' frequency of in class ICT use survey	▪ Descriptive statistics
4.	▪ Feedback from 167 Primary 4 students	▪ Students' email on how they felt about learning using ICT	▪ Text analysis of students' positive and negative feeling when using ICT for their learning
5.	▪ Primary 4 students' English Test Scores	▪ English Test Scores in comparison with a comparable school	▪ *t*-test and regression analysis
6.	▪ Primary 4 Students' ICT Skills Test Scores	▪ International Competitions and Assessment for Schools (University of New South Wales) – ICT Skills Assessment for Primary 4 Students	▪ Descriptive statistics as compared to the other Singapore Schools which had taken the same assessment
7.	▪ Primary 4 students' self-reported questionnaire survey on higher-order type of learning	▪ Students' self-reflection and assessment of their own higher-order type of learning	▪ Factor analysis and *t*-tests between the school and the comparable school - scores on students' self-reported learning on problem-solving and reflective thinking

4. Key Findings

4.1. *Review of documents*

A review of the documents and reports from the school highlights the importance of taking a holistic approach towards the integration of ICT into the classrooms and curriculum (Lim, 2007). The documents and reports consists of - scheme of work, lesson plans and reports written. They suggest the importance of technological infrastructures, teacher beliefs and practices, curriculum, leadership and professional development for the successful integration of ICT into schools and the classrooms (see Tay, Lim, & Lim, 2013 for details). In short, ubiquitous use of ICT in the school requires extensive efforts and resources.

4.1.1. *The English curriculum – Integration of ICT into teaching and learning*

The review of school documents regarding the planning of the English curriculum, jointly planned and designed by the teachers and administration, suggests that the English curriculum aims to provide students with a strong academic foundation and also to offer them the opportunity to acquire higher-order type of competencies that will empower them to envision for the future and contribute to make a difference. It also aims to prepare students to be confident, savvy and effective communicators in a media-rich environment where pupils develop skills and competencies to use digital media to express their ideas and share their creative vision effectively.

The aims are achieved via the implementation and usage of various ICT tools according to pedagogical decisions, in lower and upper primary curriculum.

For the lower primary years, ICT practice such as the Digital Story Telling (DST) is used at the primary one and two levels to equip students with the skills to create their own digital stories. This creation process requires pupils to write, select appropriate and relevant visuals and music for their stories, and record a narration of their stories. Presentation software applications are used to empower pupils to create their stories. The use of these simple technologies provide pupils with the opportunities to practise and acquire the skills required for writing and oral proficiencies, media and information literacies. For the upper primary years, students use open-source learning management system, blogs, and a game-like virtual learning environment.

The school's curriculum offers learning and teaching experiences leading to the acquisition of specific language skills and competencies. The curriculum also stretches the students by providing them with authentic and enriching learning experiences through learning journeys and enrichment activities.

4.1.2. *Pervasive use of technology – A concerted whole-school-effort*

One significantly different practice of the school is the pervasive use of ICT, as an enabler in extending and integrating the curriculum. This has been a strategic thrust that is endorsed by the staff, students and also parents of the school since its inception. The

use of ICT was explicitly spelled out and included in the curriculum. In addition, the technological infrastructure was also progressively improved throughout this course of study. Teachers also continuously update and upgrade themselves in the use of ICT for teaching and learning via the various means of professional development opportunities.

The school's one-to-one computing programme, introduced to pupils at the primary four level, opens up immense possibilities for learning and teaching. As pupils strengthen their foundation in creating oral and written narratives through the DST in the lower primary years, they move on in their upper primary years to explore the world around them through online research and consolidate their learning through oral and written report and information presentations, which are easily communicated via technologies such as presentation, word processing and blogs.

4.2. *Interviews with teachers*

A total of five teachers taught the seven Primary 4 English classes. More detailed information of the teachers who were interviewed is found in Table 2 below. Two of the teachers taught two English classes as shown in Table 2. All the teachers were interviewed individually so that the responses from the teachers could be independent of and uninfluenced by one another. These sessions took the form of informal interviews to find out how they had integrated ICT into their lessons. All the interview sessions were tape-recorded and transcribed for analysis. The interviews were conducted in May 2011.

4.2.1. *ICT and the teaching of English*

The quiz module in the learning management system is the most frequently used tool by the teachers to facilitate teaching English. The self-marking task available in the quiz module was time-saving. In addition, students were given comments immediately and were more driven to reflect and get the right answer. Observations showed that students tried many times to get the right answer after the online system prompted them that they

Table 2. Teachers who taught Primary 4 English and the number of years of experience.

Class	English Teacher	No. of Years of Experience
1	Teacher A#	6
2	Teacher B	7
3	Teacher C#	9
4	Teacher D	8
5	Teacher E	10
6	Teacher A#	6
7	Teacher C#	9

# denotes the same teacher teaching two different classes of the same subject. For instance, Teacher A taught both Class 1 and 6 for English.

were wrong. Item analysis was also made simple for the teachers. Through the online quizzes, students were able to apply and strengthen the content knowledge that they have learned.

Teachers also set up blog sites for the sharing of online teaching and learning materials. These blog sites also served as platforms for students to upload their compositions so their classmates and teachers could exchange pointers and remarks to further improve the flow and idea of their writings. They could compile the writings of all the students there as well.

On top of that, the English department also subscribed to an online reading comprehension portal where students could learn by accessing the online digital stories available at their own level of proficiency. Students would go through the levels at their own speed and readiness. Teachers indicated that students generally enjoyed the online reading comprehension portal which helped them improve.

The English teachers piqued their students' interest through the writing of digital stories, a main instructional methodology for the picking up of languages and media literacy techniques. The approach went like this: students first employed a suitable software programme to formulate their own digital story, which they craft using their words, visuals and sound recordings of their own narration. Prior to the finishing of their digital storytelling assignments, students were exposed to a framework of preparation exercises; which included the brainstorming of ideas for characters in groups, coming up with storylines and recording their stories. Teachers provided feedback and guidance throughout the process. Upon completion, the finished stories were published and circulated on the school network and the Internet through blog sites, so that everyone could look at it and offer their opinions or encouragement. The students were engrossed and enjoyed the process of turning their ideas into words that were accompanied by vibrant pictures and music. ICT expedited the presentation of their stories and students could easily generate and edit their stories and learn from each other in the process. The students could keep recording the readings until they were happy with it.

4.2.2. *Teachers' reflections and thoughts about students' learning*

Teachers who were interviewed, unanimously reflected that the use of ICT in their English classes were engaging and motivating in learning and academic tasks. They also felt that it could facilitate the learning of the higher-order type of thinking skills. However, they also raised concerns, just like the literature reviewed, that ICT seemed to engage and motivate their students but the teachers were not certain that this would lead to better performance in students' English test scores. Teachers also shared that the use of ICT required more effort to prepare lessons, technical support and resources (i.e. technological infrastructures).

4.3. *Frequency of ICT use in various English language classes*

All students from the Primary 4 level classes, participated in an online questionnaire survey regarding their frequency of ICT usage in their English classes. The details of the

Table 3. Frequency of ICT use in various English Language classes.

Class	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	32	4.56	1.883	.333	3.88	5.24
2	31	4.39	1.801	.324	3.73	5.05
3	32	5.72	1.689	.299	5.11	6.33
4	30	5.93	1.596	.291	5.34	6.53
5	28	5.46	1.710	.323	4.80	6.13
6	31	5.00	1.549	.278	4.43	5.57
7	32	5.09	1.573	.278	4.53	5.66
Total	216	5.16	1.750	.119	4.92	5.39

mean frequencies are reported in Table 3. The frequency of use is based on a Likert-scale of 1 to 7 (1 = once a month, 2 = once every 3 weeks, 3 = once every 2 weeks, 4 = once every 10 days, 5 = once every week, 6 = once every 2 to 3 days and 7 = once every day). A mean value of 5.16, on a scale of 7 being most frequently used, indicated that the frequency of ICT use in English language classes has been high.

4.4. *Feedback from students*

In general, the students commented that they were satisfied with the use of their notebook computers. They found it interesting, useful and easy to use. They used their notebook computers to access the Internet and school's learning management system to learn new knowledge, concept and words. However, the students also complained about the computer viruses, small computer screen, battery lifespan, weight of their notebook computers, slow Internet connect speed and Internet connection errors.

The Primary 4 students were asked to respond via email on how they felt about their use of their own personal notebook computers. 167 out of the 225 students responded to the request. Text analytics software was used to analyse the students' responses and the responses were generally positive and encouraging. The responses from the students were sorted into positive and negative comments. The three positive categories and their respective counts were: (a) positive comments on notebook computers – 126, (b) use of notebook computer for learning – 73 and (c) learning of new words with computer – 41; making up a total of 240 counts. There were two negative categories and their respective counts were: (a) negative comments on notebook computers – 40 and (b) comments on network and other technical glitches – 23; making up a total of 63 counts. The positive comments were 3.8 times more than the negative ones (see details in Table 4).

Table 4. Analysis of positive and negative key words used by students.

No.	Category - Positive	Phrases and key words used	Counts
1	Positive comments on notebook computers	website & interesting, notebook computer & able to use, notebook computer & satisfied, notebook computer & fun, notebook computer & appropriate, website & would recommend, website & useful, notebook computer & good, notebook computer & like, notebook computer & powerful, notebook computer & interesting, notebook computer and useful, Beacon Portal & varied, notebook computer & excellent, notebook computer & easy to use	126
2	Use of notebook computer for learning	notebook computer & learn new things, access new website, new website & strategies for learning, Beacon Portal & postings, notebook computer & easier, access Beacon Portal, access & science websites, quizzes & Beacon Portal, notebook computer & better, notebook computer & easier	73
3	Learning of new words with notebook computer	online dictionary to find words, learn words that I do not know, highlight words that I do not know, find out meaning of words that I do not know, search for meaning of words, access website to check up words that I do not know, save time	41
		Total	240
No.	**Category - Negative**	**Phrases and key words used**	**Counts**
1	Negative comments on notebook computer	computer & virus, playing of online games during lessons, small computer screen & bad for eyes, sometime did not get chance to use computer in school, heavy notebook computer, change to a lighter notebook computer, technical glitches, internet connection problems, run out of battery	40
2	Comments on network and other technical glitches	internet access & not easy, internet connection & slow, connection & problem, internet & error, make the internet faster, internet loading & slow, more access points in the classrooms, more internet access cable should be provided, internet & frustrating, internet access & faster, internet & dangerous	23
		Total	63

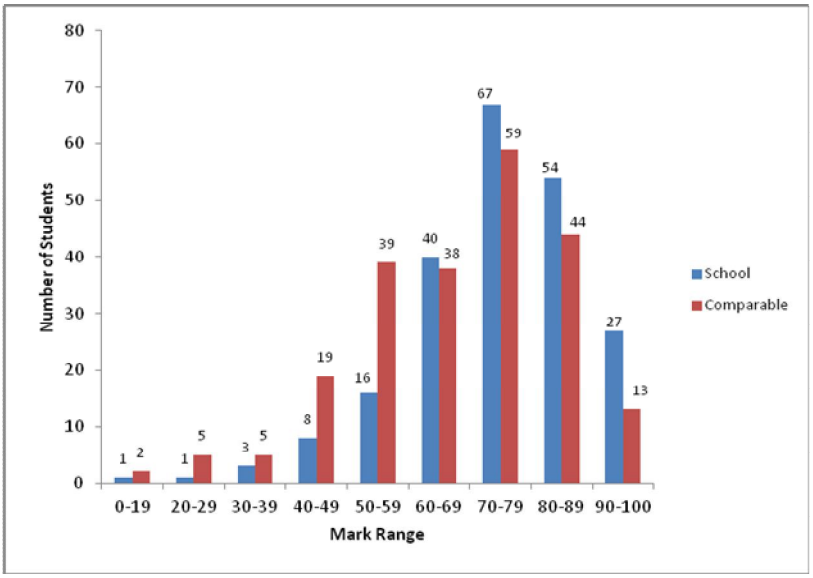

Figure 1. Mark range of English test with a comparable school.

All in all, the feedback from the students regarding the use of their notebook computers in school was positive with mainly technical related complaints. With feedback from the students, the ICT department worked with the network providers to monitor the Internet speed. The 5 mbps line was upgraded to 200 mbps fibre optic connection. In addition, teachers and technical personnel prepared simple instructions for students to better manage their computers' battery lives by using the power management software tool. As for the computer screen size issue, the school's ICT department recommended computers with 13 inch screen size. Teachers also talked and reminded students to pack their bags according to their timetables to avoid school bags that were overloaded.

4.5. *Students' English test scores*

All the Primary 4 students (aged 10) took a 38-item (48 marks) English test with a comparable school. The test scores were converted to 100%. The paper was in the form of multiple-choice questions, fill-in-the-blanks and open-ended responses. The students were tested on their vocabulary, grammar, cloze, editing and comprehension. A total of 440 Primary 4 students took the English test with 216 from the school and 224 from the comparable school. The mean scores were 73.87 and 67.38 between the school and the comparable, respectively. The mean difference between the schools was significant at t (434) = 4.414, $p < 0.001$. The effect size between the two means according to Cohen's d was 0.4057 (small-medium effect size). Figure 1 and Table 5 show the mark range of the

Table 5. Descriptive statistics of English Test Scores between the school and the comparable school.

		N	Mean	Std. Deviation	Std. Error Mean
English Test Scores	School	216	35.4606	6.92935	.47148
	Comparable	224	32.3415	7.87746	.52633

English test between the schools and the statistics (mean, standard deviation and standard error mean) of the test scores of the two groups of students.

A non-linear regression analysis on the frequency of ICT usage during English lessons and the students' English results during their first semester assessment shows that the frequency of ICT usage during English lessons had an impact on the students' English test scores. From the model summary table (see Table 6a), the frequency of ICT usage in English language classes accounted for 2.7 percent of the variance in the English language test score during the first semester assessment. The ANOVA analysis (see Table 6b) showed that the regression was statistically significant – F (1, 214) = 6.939, $p < 0.01$. The t value ($t = 205.627$, $p < 0.01$) for the constant showed that the intercept was significantly different from zero and the t value for frequency of ICT usage during English lesson ($t = -2.312$, $p < 0.01$) also revealed that the regression was significant (see Table 6c), suggesting that the frequency of ICT usage during English lessons had an impact on the English performance of the students.

Table 6a. Model summary of the regression analysis.

R	R Square	Adjusted R Square	Std. Error of the Estimate
.177	.031	.027	.187

The independent variable is: Frequency of ICT usage during English lessons

Table 6b. ANOVA summary of the regression analysis.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.243	1	.243	6.939	.009
Residual	7.505	214	.035		
Total	7.748	215			

The independent variable is: Frequency of ICT usage during English lessons

Table 6c. Coefficients of the regression analysis.

	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	*t*	Sig.
Frequency of ICT usage during English lessons	-.166	.063	-.177	-2.634	.009
(Constant)	4.191	.020		205.627	.000

The dependent variable is: English Results for Semester Assessment 1 - 2011

4.6. *Students' ICT skills test scores*

The Primary 4 cohort took part in the International Competitions and Assessments for Schools (ICAS)[*] – Computer Skills 2011 and obtained a mean score of 20.1 as compared to Singapore average score of 18.6. The *t*-test between the mean score of the Primary 4 cohort of the school and other students in Singapore showed statistical significance ($t(3581) = 4.1269$, $p < 0.01$). The details are presented in Table 7a.

Table 7a. Coefficients of the regression analysis.

	No. of Students who took test in School	No. of Students who took test in Singapore	Max Possible Score	School Mean Score	School Std Dev	Singapore Mean Score	Singapore Std Dev
Primary 4 2011	214	3369	35	20.1	4.4	18.6	5.2

The school's Primary 4 cohort outperformed in all areas assessed, including general skills, word processing, graphics/multimedia, Internet/email and databases/spreadsheets. As compared to the other who had taken the computer skills assessment, students from the school performed particularly well in the area on graphics and multimedia, with a mean difference of 0.8 (see Table 7b).

[*] International Competitions and Assessments for Schools (ICAS) is conducted by Educational Assessment Australia, UNSW Global Pty Limited. UNSW Global is a not-for-profit provider of education, training and consulting services and a wholly owned enterprise of the University of New South Wales.

Table 7b. Coefficients of the regression analysis.

Area Assessed	Max Possible Score	School Mean Score	Singapore Mean Score	Difference in Mean Score
General Skills	7	4.1	3.9	0.2
Word Processing	7	4.5	4.3	0.2
Graphics/Multimedia	7	4.3	3.5	0.8
Internet/Email	7	3.7	3.6	0.1
Databases/Spreadsheets	7	3.4	3.3	0.1

4.7. *Students' self-reported questionnaire survey on critical problem-solving and reflective thinking (higher-order type of thinking skills)*

4.7.1. *Students' self-reported questionnaire survey*

This section on the students' self-reported questionnaire survey on critical problem-solving and reflective thinking (higher-order type of thinking skills) attempts to gather and compare the quantitative feedback from the students of the school in this study and the comparable school.

For the purpose of this research study, we focus on two possible aspects of the higher-order type of thinking (i.e. problem-solving and self-reflective thinking of the students). A self-reported questionnaire survey was developed based on the literature reviewed, Internet and database searches and discussions among the authors. The survey instrument was statistically validated with both exploratory and confirmatory analysis (see Appendix for details). The main objective of this survey was to have a better understanding on how students' perception differed between the school (i.e. students who were exposed to one-to-one computing) and the comparable school in terms of their problem-solving and self-reflective thinking skills.

4.7.2. *Means testing (t-test) on each of the two constructs*

We investigated if there were any difference between the two schools in terms of the creative problem-solving and critical reflective thinking constructs. We derived mean scores for each of the constructs and compared the scores between the schools with results as follows, using the *t*-test procedure. A total of 211 and 226 Primary 4 students from the school and the comparable took part in this self-reported questionnaire survey.

4.7.3. *Problem-solving*

Based on the Levene's test of equality of variances, $F = 4.068$, $p < 0.05$, which assumed different variability between the two schools, we proceed to look at the results to the variance not assumed *t*-test, with results $t\,(421) = 0.687$, $p > 0.05$, $d = 0.07$. No statistical

difference between the two schools was found in terms of the mean problem-solving scores.

4.7.4. *Reflective thinking*

Based on the Levene's test of equality of variances, $F = 11.616$, $p < 0.05$, which assumed different variability between the two schools, we proceed to look at the results to the variance not assumed *t*-test, with results $t\ (405) = 1.95$, $p > 0.05$, $d = 0.19$. No statistical difference between the two schools was found in terms of the mean reflective thinking scores.

5. Discussion

5.1. *Level of engagement and motivation*

From the above qualitative findings, it seems to suggest that students' level of engagement and motivation were high when ICT was used in their English lessons. Teachers reflected that students were generally engaged in their work when ICT was used. However, there were concerns over whether students were indeed engaged and motivated with the content to be taught and acquired. Or were they merely engaged with the technical and play aspects found with the usage of computers. Teachers were concerned that the students were engaged with other elements other than the content knowledge to be covered. Students may be engaged behaviourally but not cognitively.

At times, ICT was a device of distraction for the students, rather than a tool for learning, especially when students drifted away to social networking, online gaming or watching of videos for their personal entertainment instead of focusing on academic related learning tasks or activities. Another possible source of distraction could also be technical hiccups during lessons, as teachers and students alike would get distracted from the focus at hand.

Other than using software-based classroom management systems to control and monitor the students' behaviour with their computers, a more effective and longer term suggestion would be to constantly teach and inculcate in students the lifeskill of being able to stay on-task (i.e. to stay focused and not to deviate and get distracted). Giving clear goals or deliverables by the teacher to the students, could help students in staying on-task. Like in the normal classroom, the teacher needs to manage the students' discipline as well as provide orienting activities (Lim & Chai, 2004) during the program and guidance to the students when they encounter either technical or content-related issues. Lim and Chai (2004) stress the importance of orienting activities in ICT-based lessons. These orienting activities include - introductory sessions to ICT tools, advance organisers and instructional objectives, worksheet and checklist, and ICT and non-ICT tools for post instructional reflections.

Teachers need to take the necessary actions to help students be on-task and more aware of the possible pitfalls of using technology to engage students in academic related work; technology can be a tool for engagement, it can also be a tool for distraction.

5.2. *Students' English test and ICT skills scores*

On average, the students' English test scores were higher than the comparable school. The difference in the test scores between the schools was found to be statistically significant. This suggests that the use of ICT does have a positive impact on the learning of the English language, at least in terms of the test scores. The regression analysis suggests that ICT accounted for 3.1 percent of the variance in the English test scores. This further suggests that there is a correlation between the frequency of ICT use and English language test scores. In addition, the students also scored well for their ICT skills test as compared to the national cohort who had taken the same test.

These findings suggest that the use of ICT and in particular the use of notebook computers, coupled with the Internet and the purposeful integration of its use into the teaching of the English language could boost both the students' English test scores and also their ICT skills.

5.3. *Students' feedback on the program and usage of ICT in class*

On the whole, the feedback from the students was positive. General sensing is that students had enjoyed the use of ICT for their learning. The complaints were mainly due to technical glitches, such as, slow Internet connection, short battery span, small computer screen size and the weight of the computer. On an average, students' frequency of ICT usage during English lesson was relatively high at 5.16 on a scale of 7 being most frequent use.

The high frequency of ICT usage during English lessons came about because the English curriculum was planned and designed to incorporate technology into it. Purposeful planning is necessary for such a high usage rate.

5.4. *Extensive technological infrastructures and effort by teachers*

The interview with the teachers and review of documents, reflect sentiments similar to the literature reviewed; that more effort and extensive technological infrastructures were required for the implementation of a one-to-one computing learning environment. For instance, the wireless network infrastructure would require more planning, effort, manpower and financial resources. Teachers would also need extra effort to plan and prepare lessons that use ICT. Professional development would be another area to look into. Teachers would require the pedagogical know-hows to more seamlessly integrate ICT into their lessons.

There are two critical areas that require real thinking through for any school considering to embark on the introduction of pervasive use of ICT for teaching and learning (e.g. one-to-one computing), namely - the technological infrastructures and the additional efforts required of the teachers involved. Even when financial considerations, affordances of ICT infrastructure, are not an issue, we need to be aware that extra effort would be required for teachers to plan for ICT integration. In addition, teachers would also need to constantly upgrade and update their technological, pedagogical skills and

knowledge in order to be effective and updated with their use of technology in their teaching and classrooms.

5.5. *Problem-solving and reflective thinking*

The interviews from teachers seem to suggest the possibility of the facilitation of the learning of higher-order type of thinking skills (i.e. problem-solving and reflective thinking) by the students. Lim and Tay (2003) and Passey (2000) also suggested that ICT could be used to facilitate the learning of higher-order type of thinking skills. However, no statistical difference was observed on students' self-reflected level of critical problem-solving and self-reflective thinking skills between the school and the comparable school.

This finding suggests that teachers from the school in this study may need to look into how they could more effectively use ICT to facilitate the acquisition of higher-order thinking into their lessons.

6. Conclusion

All in all, it seems that ICT does have an impact on the learning of English in the primary or elementary level, especially in areas of engagement, motivation and test scores. Students generally favour the use of ICT for their learning of English. However, it is important to consider the extra effort, manpower and technological infrastructure overheads and investments when embarking on such an endeavour. It is also worth the effort to further explore how to reduce students' off-task (e.g. social networking and playing of online games) activities with their computers. It is also necessary to look into the serviceability of the technical infrastructure and equipment for more seamless use. The relationship between ICT use and the facilitation of the acquisition of higher-order type of thinking skills also deserve more in-depth study and exploration; in terms of its relationship to the use of ICT and higher-order type of thinking skills could be more accurately, easily and efficiently measured.

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Appendix A. Statistical Validation of Student Self-Report Questionnaire Survey

The student self-reported questionnaire survey for students' critical problem-solving and self-reflective skills was validated with a total of 890 students' (Primary 3 and 4 students) participation (434 from the school in this study and 456 students from the comparable school). The self-reported questionnaire survey items were presented using a 7-point Likert response scale with 1 = strongly disagree and 7 = strongly agree. On average, the questionnaire did not take more than 5 – 10 minutes to complete. The questions were derived through literature search, discussion among the authors and validation with experienced teachers.

A.1. *Principal components analysis*

An exploratory factor analysis was conducted using the principal components analysis. In particular, the varimax rotation was employed onto the 15 items as shown in Table 8a. Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.926, evident that the sample size was sufficient, where values above 0.9 were considered excellent (Hutcheson &

Table 8a. Descriptive statistics of the 15-item proposed for "Higher-Order-Thinking".

Item		Mean	SD	Skewness	Kurtosis
1	I look at things from different ways.	4.74	1.585	-.497	-.100
2	I know which subjects I am good at.	6.11	1.472	-1.878	2.949
3	I identify the real problem and the cause of it.	5.03	1.579	-.639	-.163
4	I use different methods to find the solution, e.g. thinking, finding information on the Internet, in books, etc.	5.22	1.664	-.771	-.210
5	I combine or change current ideas/things into completely new ideas/things.	4.70	1.638	-.462	-.371
6	I find different ways to solve a problem.	5.16	1.566	-.692	-.068
7	I organise my work by their importance and how quickly they must be done.	5.15	1.635	-.733	-.143
8	I know which subjects I am not so good at.	6.16	1.411	-1.900	3.160
9	I check to see how far the problem has been solved.	4.93	1.574	-.522	-.248
10	I can find the good sides for different ideas.	5.06	1.646	-.600	-.298
11	I choose the best way, out of a list of ways, to solve a problem.	5.05	1.592	-.635	-.212
12	I can find the bad sides for different ideas.	4.65	1.865	-.486	-.699
13	I use good reasons or facts to support my decisions.	5.08	1.581	-.670	-.099
14	I create new ideas.	5.09	1.677	-.617	-.444
15	Creative thinking-I create unique solutions to solve problems.	4.77	1.698	-.422	-.567

Sofroniou, 1999). Bartlett's test of sphericity, χ^2 (153) = 2341.651, $p = 0.00 < 0.05$, also showed that correlation was sufficiently large for principal components analysis. In accordance to recommendations from Kaiser (1960), components with eigenvalues greater than 1.0 were adopted. As shown in Table 2, two components with eigenvalues more than 1.0 were yielded and it composed of 50.65% of the total variable explained. Although variance explained was but over 50% representation, most of the factor loadings were above 0.5 which bears practical significance and was therefore retained for further analysis (Hair, Black, Babin, & Anderson, 2010). Furthermore, similar test with oblique rotation (Promax: Kappa = 4) showed consistent results of two constructs. To validate the items within each of the two constructs, a reliability analysis, in the form of Cronbach's (1951) alpha was used. Cronbach's alpha indicates the overall reliability of a construct and values around 0.8 are considered good (Field, 2009). In accordance to recommendations by Cronbach, scores of the two constructs were 0.771 and 0.898 (see Table 8b) and these were considered acceptable and good. With the above analysis, we therefore derived two constructs, namely, problem-solving and reflective thinking. Based on initial literature review, these are in turned related to higher-order thinking skills.

Table 8b. Principal Component Analysis and reliability of the proposed 15 items.

Item/Construct	1	2
Eigenvalues	6.334	1.263
% of variance explained	35.258	15.389
Reliability Test: Cronbach's Alpha	0.898	0.771
I create unique solutions to solve problems.	0.786	
I can find the good sides for different ideas.	0.705	
I choose the best way, out of a list of ways, to solve a problem.	0.687	
I create new ideas.	0.683	
I find different ways to solve a problem.	0.664	
I use good reasons or facts to support my decisions.	0.662	
I combine or change current ideas/things into completely new ideas/things.	0.640	
I check to see how far the problem has been solved.	0.635	
I can find the bad sides for different ideas.	0.595	
I identify the real problem and the cause of it.	0.556	
I look at things from different ways.	0.550	
I use different methods to find the solution, e.g. thinking, finding information on the Internet, in books, etc.	0.539	
I organise my work by their importance and how quickly they must be done.	0.488	
I know which subjects I am not so good at.		0.870
I know which subjects I am good at.		0.864

A.2. *Confirmatory factor analysis*

Confirmatory analysis was used to examine the factorial structure of the 15 item scale and AMOS 17.0 was used for this analysis. A proposed model was built and model fit was assessed by a number of indices. Firstly, as multivariate normality of the data affects the reliability of the structural equation models, the Mardia's coefficient (1970), which is a standard measure of multivariate normality, was first consulted. The coefficient, 109.087, was lower than the recommended threshold of 225 (15×17) and based on the recommended value of $p*(p+2)$, where p is the number of observed indicators, the requirement is satisfied hence the data for this study was deemed to be adequate for confirmatory factor analysis.

Next, we turn our attention to the model fit indices. As chi-square has been found to be too sensitive to sample size, the ratio of chi-square to its degree of freedom was used (CMIN/DF) and scores of 3.0 or below (CMIN/DF = 1.925) are deemed to be an acceptable fit between the hypothesized model and sample data (Carmines & Mclver, 1981). Two incremental fit indices were used. The comparative fit index (CFI) was above 0.9 and deemed to be of a well-fitting model (Bentler, 1992) and values 0.95 has been deemed to be more acceptable (Hu & Bentler, 1999) (CFI = 0.966 > 0.95). The Tuker Lewis index (TLI) was above 0.95 and indicative of a good fit (Hu & Bentler, 1999) (TLI = 0.960 > 0.95). In accordance to suggestions by MacCallum and Austin (2000) that the root mean square error of approximation (RMSEA) should use routinely due to

Table 8c. R^2 Results of the confirmatory factor analysis of the 15 item Higher-Order Thinking Skills.

Item	R^2
I know which subjects I am good at.	0.726
I can find the good sides for different ideas.	0.539
I know which subjects I am not so good at.	0.538
I choose the best way, out of a list of ways, to solve a problem.	0.505
I use good reasons or facts to support my decisions.	0.481
I create unique solutions to solve problems.	0.469
I check to see how far the problem has been solved.	0.450
I find different ways to solve a problem.	0.445
I create new ideas.	0.430
I combine or change current ideas/things into completely new ideas/things.	0.415
I identify the real problem and the cause of it.	0.386
I use different methods to find the solution, e.g. thinking, finding information on the Internet, in books, etc.	0.360
I can find the bad sides for different ideas.	0.285
I organise my work by their importance and how quickly they must be done.	0.267
I look at things from different ways.	0.210

Table 8d. Confirmatory Factor Analysis of model comparison.

Model	CMIN/DF	TLI	CFI	RMSEA [Lower, Upper Bound]	Model Description
1	1.925	0.960	0.966	0.046 [0.035, 0.056]	15-item model with 2 constructs
2	2.938	0.916	0.928	0.066 [0.057, 0.075]	14-item model with 2 constructs

reasons like sensitivity to model misspecifications and model quality; it is recommended that values lesser than 0.08 indicate an acceptable fit (MacCallum, Browne, & Sugawara, 1996) with values less than 0.05 indicating a good fit (RMSEA = 0.0466 < 0.05).

A.3. *Model comparison*

In accordance to suggestions by Noar (2003) and Teo et al. (2010), fit indices of alternative models allow for comparison of proposed instruments. Based on the R^2 values of the items (Table 8c), the item with the lowest R^2 (item 1, R^2 = 0.210) was removed from the proposed model and a 14-variable model was re-run. Shown in Table 8d, the Tuker-Lewis Index and the Comparative Fit Index both fell below 0.95 (TLI = 0.916 < 0.95, CFI = 0.928 < 0.95), indicating a less than acceptable fit. Furthermore, the RMSEA was above 0.05 which though is acceptable, it does not indicates a good fit (RMSEA = 0.072 > 0.05).

On this basis, we concluded that model 1 with 15-items and two constructs was retained as the model of better fit (See Table 8d and Figure 2 for the proposed model).

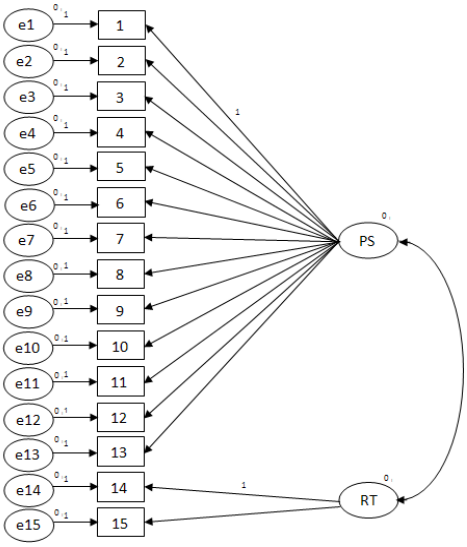

Figure 2. Proposed model for the 15-Item self-report questionnaire survey for Higher-Order Thinking.