The global level of economic, ecological, social, political and cultural integration across nation states and the rapid advancement of technology have brought about transformations that are part of globalisation. Our students are expected to be agents of change rather than passive observers of world events; and at the same time, to live together in an increasingly diverse and complex society and to reflect on and interpret fast changing information. In such a new world order, the holistic development of our students, namely in the cognitive, aesthetics, physical, social and moral, leadership and global domains, is pivotal. This edited book provides descriptive and interpretive accounts of how an elementary school in the FutureSchools@Singapore programme creates holistic technology-enhanced learning experiences for its students at the classroom and school levels. By documenting these accounts and linking them to student learning outcomes, the school will lead the way in providing possible models for the seamless and pervasive integration of information and communication technologies (ICT) into the curriculum for the holistic development of our students.
Creating Holistic Technology-Enhanced Learning Experiences
Tales from a Future School in Singapore

Edited by
Lee Yong TAY
Beacon Primary School, Singapore

and

Cher Ping LIM
The Hong Kong Institute of Education, China
# TABLE OF CONTENTS

**Editorial**  
*Lee Yong Tay & Cher Ping Lim*  
  
vii

**Foreword by Leslie S. Conery**  
  
xiii

**Foreword by Nancy Law**  
  
  xv

**Chapter 1**  
Information and Communication Technologies (ICT) in Primary Education: Opportunities and Supporting Conditions  
  
*Cher Ping Lim & Grace Oakley*  
  
1

**Chapter 2**  
Factors Affecting the ICT Integration and Implementation of One-to-One Computing Learning Environment in a Primary School – A Sociocultural Perspective  
  
*Lee Yong Tay, Siew Khiaw Lim, & Cher Ping Lim*  
  
19

**Chapter 3**  
Teaching with Technology in a Future School in Singapore: A Mathematics Teacher’s Experience  
  
*Sze Yee Lye & Daniel Churchill*  
  
39

**Chapter 4**  
Digital Storytelling and Drama in the English Language Classroom  
  
*Prudence Ellen Wales & Melwani Mohamed*  
  
59

**Chapter 5**  
The Use of Knowledge Building tool for Science Learning in an Elementary School  
  
*Maneatonufus Yusoff, Sandy Yu, & Chun Yen Chang*  
  
75

**Chapter 6**  
‘I Can Animate!’ Project: A Multimodal Construction and Analysis of Animated Digital Stories  
  
*Serene Qing Yun Lee & Caroline Ho*  
  
93
Chapter 7
The Making of the Future School: Experiencing the Process; Processing the Experience
Nasrun Bin Mizzy & Yan Ping Fang
117

Chapter 8
Developing and Sustaining Practitioner Research in Schools: Lessons from Teachers as Researchers in a Future School in Singapore
Suraj Nair
141

Chapter 9
A reflection of Our Journey into the Future – Sustaining and Transferring our Practices
Boon Cheng Lim & Lee Yong Tay
177

Discussant Chapter 1
Observations from Afar: An Australian Response to Tales from a Future School in Singapore
Margaret Lloyd & Geoff Romeo
189

Discussant Chapter 2
Looking Back at the Future School Journey: A Brief Review of the Teachers and Leaders’ Design and Research Effort from the Framework of Technological Pedagogical Content Knowledge
Ching Sing Chai & Chin-Chung Tsai
195

Discussant Chapter 3
Teachers as Agents of Change: Blending Research and Practice and Thoughts on Future Teacher Professional Development Opportunities
Tim Rudd
201

Discussant Chapter 4
Accelerating Educational Transformation through ICT: A Global Perspective
James Bernard
209

Contributors
217

About the Editors
243
EDITORIAL

THE SETTING – THE SCHOOL
Beacon Primary School is located in the west part of Singapore. It started operations as a pioneer future school under the FutureSchools@Singapore programme with its first intake of Primary 1 students in 2008. The school has now about 1200 students from Primary 1 to 5 and more than 100 teaching and non-teaching staff. The school started off with only 240 Primary 1 students with about slightly more than 25 teaching and non-teaching staff in 2008.

THE SCHOOL – A FUTURE SCHOOL
Beacon Primary School is one of the three primary/elementary level future schools under this programme. To date, there is a total of eight future schools under the FutureSchools@Singapore programme – with three primary schools and five secondary and post-secondary educational institutions. The FutureSchools@Singapore programme is a collaborative project between the local Ministry of Education and Infocomm Development Authority. The school seeks to implement innovative teaching practices that leverage on technologies to better engage its learners.

THE FUTURE SCHOOL – THE JOURNEY CONTINUES
This second edited book, following the first – A school’s journey into the future – research by practitioners for practitioners – aims to document the first five years of practitioner research by teaching staff of Beacon Primary School so as to reflect and look deeper into the use of ICT into the teaching and learning processes in the classrooms, especially in the area of one-to-one computing learning environment.

Practitioner research allows teachers of the school, with advice from academics from institutes of higher learning, to research and explore on how to bring out the potentials of the use of ICT in the teaching and learning processes. Practitioner research allows teachers to review up-to-date practices through literature review, implement their innovative and creative teaching practices, and evaluate and review their practices through systematic and objective ways to gather qualitative and quantitative data – the two key words being systematic and objective. Through this more scientific way (i.e., systematic and objective), teachers and practitioner researchers can explore and reflect more deeply into their own or their colleagues’ practices and with the insights gained, increases the likelihood of achieving a transformation in the teaching practices and behaviour.
The school has since shared its experiences and insights through the hosting of overseas and local visitors, conference presentations (local and overseas international conferences), and publications in edited books and peer-reviewed international journals.

The school has successfully implemented student owned one-to-one computing learning for two years since 2011 to its Primary 4 cohorts in 2011 and 2012. In addition, the school has also successfully operationalised the digital storytelling pedagogical approach through the use of technology in the teaching and learning of languages (English, Chinese, Malay, and Tamil) in the school. The use of open-source applications (e.g., Moodle, Blogs, and Wikis) and web 2.0 tools is also widespread in the school.

THE JOURNEY – THE EXPLORATION AND INSIGHTS

In Chapter 1 by Lim and Oakley, the authors highlight the opportunities and potentials of ICT for teaching and learning in primary (elementary) education. However, they also acknowledge that ICT in the primary classrooms do not guarantee enhanced learning, though they do outline how ICT could be used to facilitate the learning of 21st century skills, literacy, numeracy and science. In addition, they also listed the necessary and sufficient conditions to support ICT for teaching and learning in primary schools. These necessary and sufficient conditions are: (1) policy and school leadership; (2) physical and technological infrastructure; (3) curriculum and assessment; and (4) professional development for teachers.

In Chapter 2 by Tay, Lim and Lim outline the factors affecting the ICT integration and implementation of one-to-one computing learning environment in a primary school context. The authors use a sociocultural perspective – activity theory – as a framework for their analysis of the various factors that could have an impact on the ICT usage in the classrooms. The authors caution that even after disregarding the issue of accessibility to technology, in this case the equipping of one-to-one computing learning environment for students, there are other mediating factors for the successful integration of ICT into the classrooms. Using Engeström’s activity theory to elicit the quaternary contradictions (i.e., to take into consideration the significant neighbouring activity systems), the following systems are listed: (1) technological infrastructures and support; (2) teachers’ beliefs and practice; (3) curriculum; (4) school leadership; and (5) professional development. The authors propose a path analysis model of ICT usage in the classrooms where school leadership, professional development and curriculum are less visible factors that support the more visible factors – ICT infrastructures and teachers’ beliefs and practices.

In Chapter 3, Lye and Churchill describe how a mathematics teacher documents her classroom practices with both qualitative and quantitative data to reflect on the way she has taught over the years since 2008. The teacher selects easily available software applications, such as freeware and cloud-based applications. She also uses standard non web-based applications, such as the commonly used word processing,
presentation, and spreadsheets software applications. She stresses that the affordance of the technological tools is the most important element to be considered – how technology could help students learn better. She uses Blogs to disseminate information regarding her mathematics lesson to students and their parents, collates freely available Internet web resources to be put on the Blogs for students to get more information or play educational mathematical games to reinforce what have been taught in her lessons. She also uses the commonly available presentation software to engage students in their model drawing for mathematic problem-solving sums and systematically documents how she has conducted her lessons. She then attempts to objectively evaluate the impacts of her teaching on her students’ acquisition of mathematical concepts and skills.

In Chapter 4, Wales and Melwani describe how they have designed a series of English language lessons incorporating drama and digital storytelling. Drama and digital storytelling are two pedagogies that are recognised for being engaging, participatory and immersive in nature. Over a period of three weeks, 32 Primary 4 students explored endangered species (e.g., the turtles) through drama and presented their findings in multiple narratives, including digital stories. The objective for this series of lessons is to know how well the students have come to understand the topic of study and develop their technical writing skills for their reports. In addition, it also evaluates the effectiveness of drama in developing the students’ understanding of the issues from different perspectives as well as builds empathy of the endangered species and cultivates better understanding of conservation. The students were found to be very engaged with the lessons. The drama activities provided students with opportunities to develop their oral skills and to embody different points of view. ICT provided students opportunities to categorise, code and synthesise information. The authors also found that the students’ third person writing skills had developed significantly.

In Chapter 5, Yusoff, Yu and Chang use ‘concept cartoon’ as a knowledge building tool for the learning of science. This study uses a social constructivist’s approach and allows students to construct their knowledge collaboratively with their peers. The authors observed that there was higher level of motivation in the learning of science among students, an increase in students’ participation and a higher participation rate from less vocal students. The authors also reflected that more efforts and considerations would be required to facilitate (or explicitly teach) students’ ability to build on their peer’s ideas. Useful teaching points were recommended by the authors to better carry out lessons using technology from a social constructivist approach.

In Chapter 6, Lee and Ho use animated digital story to engage students in the learning of English. Students retell a fable by creating simple frame-by-frame animation as a form of digital storytelling through the integration of English language, art and music. Lee and Ho use multimodality and semiotics theoretical perspectives in their analysis of students’ use of animated digital storytelling. The authors reflect that due to the increasing affordances offered by technologies, the conventional notion of being able to listen, read, speak and write would not be adequate for students to function in the new media age. They argue that the
creation of digital stories by students could facilitate the acquisition of multi-literacies – visual, technology and information literacies. According to the analysis on student’s works, their digital stories rely heavily on graphics to tell a story and the most used semiotic resource is image. The second most used multimodal resource is the frame-by-frame animation, followed by voice recordings, text and music. Lee and Ho suggest that the more important task for language teachers is to embrace and integrate the teaching of new literacies vis-à-vis the learning of traditional literacy so that students would be more ready for the 21st century world.

In Chapter 7, Mizzy and Fang use narrative inquiry to gain better insights into the challenges faced in development and critical factors that ensure the sustainability of the first elementary level future school in Singapore. The pioneer team members started off searching for what a future school entailed. Much time and effort was devoted to this initially, through talking to educators, scholars, parents, students and industry personnel. Together with the supporting personnel from the ministry’s project group, the pioneer team proceeded to develop strategic thrusts and curriculum frameworks. The identification of a strong and forward looking core team was also another key factor in the school’s initial development; having people with the same mindsets and perspectives helped make the process of innovation easier albeit the mounting expectations and opinions at that time. The issues and challenges faced were: (1) trying to be different without being ‘too different’; (2) developing and maintaining quality staff; and (3) overcoming resistance and innovation inertia. The school sustains its innovative practices through leveraging on both emergent and mature technologies and building a community of learners through practitioner research.

In Chapter 8, Nair explores the factors that could facilitate and sustain practitioner research in schools. Through questionnaires and in-depth dyadic interviews with teachers from the school, three main themes emerge as the reasons for teachers to be engaged in research – to inform and evaluate their own teaching practices; the influence by school culture; and wanting to extend professional influence. Findings suggest the importance of a supportive school management in facilitating and sustaining practitioner research. Although teachers in this study appreciate the opportunity of teamwork and learning from their colleagues, it cannot be assumed that such collaborations would lead to positive outcomes. The lack of research skills is a factor that impeded research engagement. Nair proposes to look at this educational innovation (i.e., practitioner research) from two key elements – structural and people – from a change management perspective.

In Chapter 9, Lim and Tay reflect on their 6-year journey in the future school – starting a project is not easy; sustaining it is even more challenging. Lim and Tay describe how the school has embarked on the sustaining and transferring of its educational innovations and ICT integration with three principles – simplicity, sustainability and transferability. These efforts are: (1) creating a sustainable one-to-one computing learning environment through student computer ownership programme; (2) using of readily available, easy to use and free software applications for the integration of ICT into the classroom; (3) enhancing pedagogical practice through constant professional development and practitioner
research; and (4) transferring of innovative ICT practices with the teaching fraternity. The commitment and perseverance of those involved, strong leadership together with a high level of technical and pedagogical knowledge and skills are conditions that facilitate the implementation and sustainment of innovative practices. The authors stress that committed and capable individuals remain the single most important success factor for sustainable innovations.

INSIGHTS – FROM THE COMMUNITY

In Discussant Chapter 1, in response to the book chapters, Lloyds and Romeo highlight four key messages, the movement of ICT from periphery to the mainstream, ICT changing but not replacing school, change supported at all levels and changes in the role of the teacher. The authors call for a change to grasp the affordances of new technology in teacher education because the roles of teachers are changing and so too should the role of the teacher educator.

In Discussant Chapter 2, in their response to the book chapters, Chai and Tsai propose that the TPACK (Technological Pedagogical Content Knowledge Framework) could be used to review the chapters presented in this book. They suggest that the successful integration of ICT for learning requires teachers to have three basic forms of knowledge – technical, pedagogical and content. In addition, teachers need to also consider the intersections of these forms of knowledge, namely technical pedagogical knowledge, technical content knowledge, pedagogical content knowledge as well as technical pedagogical and content knowledge.

In Discussant Chapter 3, Rudd applauds the school’s effort in using practitioner research as a form of professional development. He reflects that professional development opportunities are very often ‘one off’, ‘one size fits all’ and ‘top down’ activities that may not have a durable impact. Although this approach is practical and maybe highly successful in many instances, it does not necessarily provide teachers and practitioners a sense of ‘ownership’; and with such a homogenised form of practice, creativity and innovation may not be well facilitated. He proposes the use of digital collaborative tools for sharing of practitioner research findings amongst practitioners and the involvement of students as co-designers of research projects. He highlights the value of practitioner research and also calls for the spreading of such a practice as a form of reaching out to a wider audience for the better sustainment of this innovation.

In Discussant Chapter 4, the final chapter, Bernard shares the concept of accelerating educational transformation through ICT from a global perspective. In order for the whole-system renewal to be effective, Bernard lists four necessary features to be in place: (1) student-driven learning must be at the core; (2) changing teaching practice to embrace technology, rather than fearing it; (3) strong school leadership; and (4) system change with strong community partnership support. He describes Microsoft Innovative Teaching and Learning (ITL) Research, with the aim of innovative teaching practice using ICT for students’ attainment of 21st century skills. The Innovative Teaching and Learning practice includes: (1)
student-centred pedagogies that offer opportunities for students to develop future skills; (2) extending learning beyond the classroom; and (3) the use of ICT to support learning. ICT could support these teaching methods by engaging students with compelling, high quality digital content, personalised learning, and provide students with tools, information and applications that can enable them to create knowledge products more easily.
FOREWORD

Some books tell a story, others serve as resources with sections tagged for future reference. This rich book edited by Lee Yong Tay and Cher Ping Lim does both.

Creating Technology-Enhanced Learning Experiences: Tales from a Future School in Singapore tells many stories. It tells about a country that invested in exploring how to use ICT to create rich learning environments to prepare their students for the future. It is also the story of Beacon Primary School and the school’s journey to be a model of effective use of ICT in primary education. A journey guided by inquiry based learning at all levels: Students, teachers, administrators, politicians, and the ICT in education community. Taken in its entirety, the book is a powerful story, still in progress, of educational change.

In addition to telling a story, Tales from a Future School in Singapore is a resource goldmine full of practical examples, citations for future reading, concrete tips, insightful reflections, and directions for further study. I found myself tagging ideas, resources, and references throughout the book and making note of how I would disseminate them to schools embarking on similar journeys. What a powerful catalyst these chapters can be for reflection, refinement and replication by other educators around the globe.

By pulling all these pieces together into a cohesive whole, editors Tay and Lim provided a launch point for other schools, school districts, and countries ready to learn from the experiences of others. Within these pages you will discover five keys for school level policy that are essential for successful ICT implementation at the grassroots level. In our work at ISTE (International Society for Technology in Education), we found that these same five elements are essential for supporting learning in the digital age and documented them as essential conditions necessary to effectively leverage technology for learning within ISTE’s NETS (www.iste.org/standards). Within this book, you will also read research conducted by classroom teachers that provides insight into the realities of what works in the classroom aligned with clear pedagogical goals along with reflections on improving classroom practice. Finally, you will reflect and look forward with leaders from around the globe about the lessons learned at Beacon Primary School.

While I read the book in a traditional format, I imagine it as a digital resource with links to further reading, videos of classroom examples, tags on every page to help search and sort for the nuggets of wisdom for reference in the future, and the ability to digitally link back to, and annotate, key points and learning. Tim Rudd reflects on the power of the “collective and collaborative approach” of sharing practitioner research and engaging in communities of practice in Chapter 12. I look
FOREWORD BY CONERY

forward seeing this work referenced and built upon in our work at ISTE and in the
global ICT in Education community.

This book is about a vision held by the Singapore Ministry of Education and
implemented by passionate skilled educators. Shared vision and a well crafted plan
for achieving the vision – steeped in innovation, collaboration, a culture of
disciplined action with ample room for failure and learning lessons along the way –
is what will change the future of education.

AFFILIATION

Leslie S. Conery
Deputy Chief Executive Officer
International Society for Technology in Education
Reforming curriculum and pedagogical practices in schools to better meet the challenges of the 21st century and integrating ICT into learning in schools have been on the agenda of many ministries of education around the world since the last decade of the past millennium. While the priorities for education reform and the reasons for introducing ICT into classrooms may not always align with each other, efforts to link the two together at the policy and organization levels are not new. In fact, international comparative studies of ICT-supported education innovation started in the late 1990s, the best known of which are the OECD cases studies of ICT and organisational change (Venezky & Davis, 2002) and the IEA case studies of ICT-supported pedagogical innovations in the SITES Module 2 Study (Kozma, 2003). These studies explored the role of ICT in reforming (or transforming) education and came to the conclusion that ICT per se cannot be the driver or catalyst for change, but where there is already a commitment to school-wide innovation and change, ICT can serve as levers to accelerate the intended changes.

The chapters in this volume go beyond documenting the courageous efforts of the teachers and school leaders in their journey to realize the vision of a “future school” today. Most of the chapters belong to the genre of practitioner research, jointly authored by teachers or leaders of the school in partnership with education researchers. Together, they make a unique contribution to the innovation literature in providing a holistic understanding of the complexities, challenges, as well as possibilities and successes in leveraging the potentials of ICT to build a school fit for the 21st century.

Beacon Primary School is not only a Future School. It was a brand new school that was expressly set up as a Future School in Singapore, a country that is well known internationally for its ICT in Education Masterplans, and the high academic achievement of its students in international comparative studies of academic ach. Singapore is not alone in having launched a number of ICT in Education Masterplans since the 1990s. However, it stands out as having an outstanding clarity and consistency in its vision, as well as continuity in having strong, supportive strategic measures in its progressive implementation. Thinking Schools, Learning Nation (TSLN) encapsulated the vision and goal for the First Masterplan launched in 1997. While TSLN is still the guiding vision, the subsequent Masterplans have set up more specific directives and foci to guide the change process. At the launch of Masterplan 2 (mp2), the Senior Minister of State for Trade and Education pointed out that the goal was

ultimately not about the use of technology, but about changing the culture of the classroom and school to support and motivate thinking and independent learning among our pupils. (Shanmugaratnam, 2002)
The FutureSchools@Singapore program was launched in 2007 as an initiative integral to mp2.

The principal and a core team of senior teachers started planning for the new school in 2007, with support from the MOE in the form of extra funding resources as well as the provision of a small group of curriculum specialists and educational technologists. Hence with legitimacy for innovation at both state and school levels, and requisite resources and expertise to forge ahead with innovations, the school seems to be (and may actually be) in the best possible setting for launching ICT-supported innovations. Readers may thus be surprised to read that even at the initiation stage, the pioneering team in the school had to “struggle with the paradox of ‘being different without being too different’” (Mizzy & Fang, this volume). The challenges are of an ecological nature (Law, Yuen, & Fox, 2011). Schools are complex systems and all parts of the system are interconnected. Classrooms are nested within schools, which are in turn nested in the wider community locally, nationally and internationally (Davis, 2008). Innovations are by definition deviations from the norm. So the process of innovation implementation needs to overcome constraints posed by the existing environment, which has been established to serve the status quo. These constraints may be physical, technological, conceptual or institutional governance in nature.

The future is inextricably connected with the present, and innovations are inextricably connected with everyday mundane practices. Introducing innovations into classrooms and schools is like introducing a foreign species into an indigenous ecology. A foreign species, depending on whether it is a plant or an animal, will compete for space/habitat and energy (sunlight, water, nutrients or food) with existing species. In most cases, foreign species will not survive in alien environmental conditions. Alternatively, surviving foreign species often become invasive species, causing the demise and extinction of less competitive indigenous species that share similar niches as well as those indigenous species that depend on the endangered species for their well-being.

The case studies of holistic ICT-enhanced learning experiences reported in this volume take up formal curriculum time in designated school subjects. Implementation of these innovations requires a distribution of school resources that is different from the mainstream, “normal” classroom, and requires the teachers and students to take on different roles in the teaching and learning process. It also requires a new expertise profile of school staff, and in the case of an existing school, it may even mean the replacement of one staff category by another (e.g. offset printing and photocopying staff to be replaced by computer technicians). So, if the goal is to sustain and scale the innovations, some species have to be replaced and become extinct. Fortunately, unlike biological species, people involved at different levels in the education system do not need to become extinct, but can grow into different roles through learning – if the appropriate conditions for learning are there. In our cross-national analyses of case studies of ICT-supported pedagogical innovations, it was found that providing architectures for learning through different professional networks is a crucial factor for innovations to become sustainable (Law et al., 2011). Practitioner research is clearly one such
mechanism/architecture. No doubt, the support and encouragement given to teachers to engage in practitioner research have contributed much to the changes achieved by the school, and to their sustainability.

I enjoy very much reading the narratives on the challenges encountered in negotiations with various external parties. I see the successes achieved through such negotiations as important contributions the school has made towards achieving the vision of sustainable innovation. There are many studies of factors contributing to sustainable integration of ICT and/or educational innovations. Having such factors in place often challenges existing norms, regulations or governance structures. The process of negotiation is also the process through which the innovation (i.e. the foreign species) creates impact on the environment. Only when the external ecological environment (i.e. the norms, practices and regulations in the wider educational context and social milieu outside of the Future School) is changed to align with the needed conditions for the innovative practices will the Future School become sustainable. Practitioner research on such negotiations can also serve as architecture to scaffold learning at the community and national levels.

This book is a valuable resource for practitioners, policy makers and researchers who believe in the transformative potential of ICT in education. There is much insight that can be gained from the richness of the analyses reported in the different chapters as well as the breadth of literature that underpins the theoretical and methodological bases of these studies.

REFERENCES


AFFILIATION

Nancy Law
Associate Dean (Development), and
Director, Information Technology in Education
The University of Hong Kong
INTRODUCTION

It is increasingly recognised by researchers, governments and educators around the world that ICT presents many opportunities for teaching and learning in primary (elementary) education. A lack of ICT in the classroom may be seen as disadvantageous for children because without access to this, they are denied opportunities to acquire some of the skills and attributes they need to become full participants in an increasingly ICT mediated and globalised world (UNESCO, 2008). Even so, it needs to be acknowledged that having ICT in the primary curriculum and classroom does not guarantee enhanced learning, and may represent little more than new means of reaching pre-existing, and perhaps inappropriate or outdated, ends (Adams, 2011). Furthermore, ICT in education needs to be supported by appropriate policies (Tondeur, van Keer, van Braak & Valcke, 2008) at all levels and effective professional development for teachers (Lim, 2007).

In this chapter we will review what existing research says about ICT in primary education. The chapter is organised into two main sections:

1. Opportunities provided by ICT for teaching and learning in primary schools in 21st century competencies, literacy, numeracy, and science;
2. Necessary and sufficient conditions to support ICT-enhanced teaching and learning practices in primary schools.

OPPORTUNITIES PROVIDED BY ICT FOR TEACHING AND LEARNING IN PRIMARY SCHOOL

It is clear that the integration of ICT in schools and classrooms must take into account many factors, including the pedagogical practices, prior experiences and attitudes of teachers and students, and the interpersonal processes (Law & Chow, 2010). The introduction of ICT invariably means that teachers must change their practices and even their philosophies, and it is not unusual for resistance to change (Guskey, 2002). Depending on all of these factors, and on the learning activities and expected learning outcomes, ICT can play various mediating and transformative roles in the learning environment. In this section, we examine the opportunities ICT provides teaching and learning in primary schools with respect to (1) 21st century competencies, (2) literacy, (3) numeracy, and (4) science.

Depending on how ICT tools are used in classroom, Lim and Tay (2003) suggested that they can be categorised as:

Information tools These are applications that provide information in various formats (for example, text, sound, graphics and video). Examples of informative tools include multimedia encyclopaedias and resources available in the World-Wide-Web (WWW).

Situating tools These are systems that situate students in an environment where they may ‘experience’ the context and happenings. Such systems include simulation, games and virtual reality.

Construction tools These are usually tools that can be used for manipulating information, organizing one’s ideas or interpretations. For instance, mind mapping or social networking applications that allow students to organize their ideas or reflections and communicate with others.

Communication tools They are applications which facilitate communication among teachers and students, such as e-mail, blogs, e-conferencing and e-discussion boards.

In addition to these four categories, ICT may also serve as tutorial and diagnostic tools. In real classroom practices, perhaps especially in primary school classrooms where integrated curriculum is commonplace, ICT often serves more than one role simultaneously. Furthermore, it is likely that developments in technology will lead to pedagogies that are unrealized and unimagined as yet, which may alter and extend the above list of roles in the future.

21st Century Generic Competencies

In many countries it is recognised that there are ‘generic competencies’, necessary for living, learning and working in the 21st century. One such generic competency is the ability to use ICT for a variety of purposes, like accessing information, communicating, building knowledge, representing ideas, problem solving, creating and developing ideas and products, collaborating, and learning how to learn. The place of ICT as a generic competency is now enshrined in policy and curriculum documents in many countries. For example, in Australia, the use of ICT has been identified as ‘general capability’, needed by all students to succeed in life and work in the 21st century (Australian Curriculum, Assessment and Reporting Authority, 2011).

Because ICT is constantly developing, opportunities for teaching and learning are also continually evolving. For example, the use of computers and the Internet no longer need to be positioned in fixed places; mobile technologies allow interaction via text messaging and access to the Internet wherever and whenever one wants. A significant development of ICT in primary classrooms is the introduction of tablet computers such as the Apple iPad. These mobile tablet devices are being introduced into primary classrooms around the world and teachers and children are finding new ways of using them to fulfil a variety
of learning goals beyond the school curriculum (Pegrum, Oakley & Faulkner, in press).

**ICT as Construction Tools**  In primary schools, children are often encouraged to construct knowledge and understandings through hands-on investigation, inquiry, and discussion. This is consistent with constructivist pedagogy, which underpins much teaching and learning in primary schools. It is also consistent with the ways of learning, communicating and working that are deemed to be generic 21st century competencies. ICT can play an important role in enabling new ways of doing this. Yang (2009) described a case in which web resources and technology are integrated as instructional and learning tools in an oral history project involving interviews with elders in the community. The researcher found that the students perceived benefits including learning the importance of teamwork, knowing how to design a homepage, having a unique experience, learning more about history, obtaining interviewing techniques, and learning how to undertake a research project. The project also provided an opportunity for students to sharpen their skills in problem solving and enhance their historical thinking to varying degrees. The most obvious outcome of this project was the students’ sense of accomplishment and pride along with self-growth (for example, confidence, self-esteem, responsibility), and empathy for the elders. Students also reported that they had learnt that historical issues can be viewed from a variety of standpoints, and that the standard history they were exposed to reflects the views of the dominant culture of the time.

**ICT as Situating Tools and Communication Tools**  Lim’s (2008) study in a primary school in Singapore provides a case of situating traditional curricular subjects in the context of global citizenship, utilizing a computer game environment called Atlantis. Set against the story of Atlantis facing ecological, social and cultural decay due to the blind pursuit of its rulers of prosperity and modernization, each student in the two classes involved in the study became the central character, who was confronted with the mission of saving Atlantis. This case study provides an account of how two classes of grade five students engaged in learning English, mathematics and science by playing the role of global citizens and solving problems as individuals or in collaboration with their fellow questers. Results indicated that this approach had positive effect on enhancing students’ learning engagement, academic motivation and social commitments.

**Literacy**  ICT has changed the nature of literacy and how it is taught, and changing the nature of literacy has, in turn, driven developments in ICT (Leu, 2000). Whereas literacy used to be about reading, writing, speaking and listening, and while the teaching and learning of literacy used to revolve around pencils, paper and books, there has in recent years been a shift to ‘multimodal literacy’ or ‘new literacies’, which involve the comprehension and creation of texts composed of multiple modes of communication, including text, audio, static and moving images (Jewitt, 2008;
Policy and curriculum documents around the world have acknowledged that, in the 21st century, texts are multimodal and that children need to be taught how to construct and comprehend such texts from the early years of school (e.g. Commonwealth of Australia, 2009).

Notwithstanding the debates that have been raging about what literacy is and how it should be defined, there has been much research and discussion in recent years about how literacy is ‘best’ taught. Although there is no consensus in many areas, there is little doubt that much effective literacy learning takes place within a context of authentic communication, problem solving and analysis of texts (e.g. Fisher, Frey, & Lapp, 2009). The use of ICT can facilitate this, although more research evidence is needed to help teachers sharpen their practice in this area.

Empirical evidence about the efficacy of ICT in literacy teaching and learning is still patchy and contradictory. Brooks, Miles, Torgerson, and Torgerson (2006) stated that there is little evidence from controlled, randomized studies that ICT can improve reading or spelling in the context of traditional printed texts. Yet, other types of research (qualitative) have suggested that there are many ways in which the use of ICT can enhance the teaching and learning of literacy (Mills, 2010). For example, several studies have indicated that the use of ICT in literacy teaching and learning may be highly motivational (Gambrell, 2006). For example, Oakley and Jay (2008) found that teaching primary literacy in the form of digital storybooks can encourage reluctant readers to read more.

In recent years, interactive whiteboards (IWBs) have become widespread in primary classroom and there are numerous ways in which these can be effectively used to teach literacy where they can facilitate modelling, explanation and demonstration, as well as classroom discussion. IWBs can also be used by small groups of children to practice and apply their learning. Lewin, Somekh and Steadman (2008) have written about the process of change in pedagogic practice that necessarily accompanies the effective use of IWBs in the classroom. They found that there was an increase in literacy performance of moderate and high achieving students who have been taught using the IWB, but lower achieving children did not seem to benefit. The benefits to average and high achieving students seem to increase with length of exposure to IWBs. Dillenbourg and Evans (2011) suggested that IWBs can be used to enhance face-to-face interactions. For example, small groups of children can gather around an IWB to discuss and build concept maps, which supports their reading comprehension and planning for writing.

**ICT as Information Tools**

In Alfassi’s (2000) study of language classrooms, the teachers developed different assignment tasks to engage their students in meaningful inquiries while using ICT as information tools. The students applied research skills as they used the Internet and CD-ROMs to search for information and apply critical judgment to determine if the information was accurate, relevant, and useful. The students also prepared electronic presentations in which texts were written, read and animated with accompanying music or sound effects. Through these electronic presentations, they improved literacy and communication skills because such presentations required them to interact with each other while using various forms of
speech, symbols and logic. The study found that, by using ICT-enabled information tools, the students had significantly improved in reading and writing.

Coiro and Dobler (2007) studied the strategies used by upper primary school children to locate and understand information on the Internet. They found that for students to read Internet texts effectively, they had to be able to make connections with their prior knowledge sources; had effective inferential reasoning strategies; and were able to self-regulate their reading processes. All these skills require a high degree of metacognitive activity, which is also demonstrated by good readers of traditional printed texts. Therefore, despite claims that Internet texts can be easier to comprehend due to supportive features like links to video clips and further explanations, it seems that the comprehension of Internet texts is highly complex and teachers’ support is needed for primary students to make sense of information on the Internet.

**ICT as Tutorial Tools**

In the literacy area, ICT used as tutorial tools have often been limited to lower level skills, such as learning phonics, sight words and spelling. Research has shown that ICT can play a part in helping children learn to spell, at least as effectively as traditional methods can (Torgeson & Elbourne, 2002). Many spelling programs are in a game format, which can encourage children to practise and analyse the graphophonic and morphological components of words in an engaging way. In a study conducted by Brooks et al. (2006), a computer program was designed to enhance students’ reading and spelling through the improvement of phonological awareness. Research has also shown that students with reading difficulties can learn to decode words more effectively when given speech feedback from computers. Wise, Ring, and Olson (2000) found that computerized phonological training supports accurate decoding in reading, for example. For children with visual tracking difficulties, applications are available that can help them track print and minimise accidental skipping by highlighting words or lines (Fasting & Lyster, 2005).

Some tutorial programs can facilitate the learning of more complex literacy skills and understandings. Several studies have examined use of ICT as tutorial tools in English as Second Language (ESL) classrooms. Lirola and Cuevas (2008) found that by using a combination of computer programs, students improved their writing; Edwards, Monaghan and Knight (2000) argued that bilingual stories in interactive software provided a basis for activities and discussion and could increase students’ language awareness and foster their positive attitudes towards language learning.

**ICT as Situating Tools**

The virtual world, Barnsborough, described in Merchant’s (2010) study, was specifically designed for literacy learning and problem-solving. Most of the participating students in the study expressed a sense of enjoyment, motivation, and engagement when talking about their experience. Participating teachers tended to agree that Barnsborough was a useful situating tool for real-world literacy learning and teaching.

In the area of writing, Watts and Lloyd (2004) studied the impact of a web-based multimedia package called Espresso for Schools. This package has over 250
modules on a wide range of topics; each module contains video clips, interactive challenges with pictures, and optional worksheets. The interactive nature of the materials encouraged collaborative work, and the authentic and up-to-date nature of the materials provided motivation for the grade six students who participated in the study. The materials also have audio-visual effects that could be selected, rewound and fast-forwarded, allowing students some control of their own learning. The researchers believed that learning with the package allowed students to use their creativity and be active, exploratory learners.

**ICT as Construction Tools**

Digital storytelling entails telling stories with a variety of digital multimedia such as images, audio, and video – it provides a good example of ICT as construction tools. Halsey (2007), a New Zealand primary school teacher, reported how she encouraged her students to use podcasts and online publishing as new ways to learn and use literacy. She observed her students’ excitement in learning in these new ways. Publishing students’ works online also provided students with an audience and therefore an authentic purpose for learning. Halsey believed that learning with new technologies supported a constructivist approach to learning, which is generally most effective when students are allowed autonomy over their own learning process. Oakley (2003, 2005) has also provided insight into how ICT can be used to improve primary students’ reading fluency, by having small groups of children create digital stories with text highlighting – this can encourage them to think about phrasing. Creating these stories also encouraged children to analyse their narrations to check for appropriate pace, volume, intonation and accuracy.

Goldberg, Russell and Cook (2003) carried out a meta-analysis of 35 studies on the use of computers (word processors) in writing instruction and found that the writing process was ‘more collaborative, iterative, and social in computer classrooms as compared with paper-and-pencil environments’. They concluded that K-12 students who used computers to write were not only more engaged, but their written texts also tended to be longer and of superior quality.

Web 2.0 offers rich opportunities for improving the literacy skills of primary school children because it helps students construct texts and understanding collaboratively, and allows them to engage in online discussions (Handsfield, Dean & Cielocha, 2009). The researchers found that fourth grade children showed a different attitude towards writing and used different practices writing in a blog:

… they asked and responded to one another’s questions, and because they were writing for a larger audience …, they became more careful writers. Students who previously did not proofread their writing soon began adding conventional punctuation. (Handsfield et al., 2009, p. 45)

**ICT as Communication Tools**

Studies have found that ICT communication tools may provide support to students’ improvement of writing skills. For example, Shang (2007) found that students who were regular users of emails showed improvement in their writing and independent thinking. Biesenbach-Lucas, Meloni and Weasenforth
(2000) found that emails were effective for students to practice cohesive devices such as demonstrative pronouns, sentence connectors, and summative expressions. Communication tools may also be used in conjunction with other multimedia packages such as e-books with the function of chat rooms. With reference to online chat, Lai and Zhao (2006) found that ESL students in a text-based online chat room noticed more language usage errors than in face-to-face conversations. Another advantage of using ICT to write is that it can relieve problems associated with handwriting – like letter formation and alignment – and hence facilitate spelling and editing (Hartley, 2007).

Weblogging, or blogging, has also been tapped into for the purposes of literacy instruction. In Halsey’s (2007) study in a New Zealand primary school, the teacher and students built a blog which allowed children to publish and share their works with parents and children from other schools as well as the public. In his paper advocating use of weblogs to promote literacy in the classroom, Huffaker (2005, p. 96) argued that the characteristics of weblogs such as ‘personal space and linkages with an online community’ allowed individual expressions and collaborative interactions in the form of storytelling and dialogue. Importantly, like many other ICT tools, blogs allow learning to take place outside the confines of the classroom walls.

It has been shown above that there are numerous opportunities for using ICT in the teaching and learning of literacy, and there are many more that we are unable to discuss in the confines of this chapter. In the case of mathematics, there are also many exciting opportunities for the fruitful use of ICT, and these are outlined below.

**Mathematics (Numeracy)**

The purposes and pedagogies associated with mathematics have changed in recent decades:

The traditional view of mathematics which focused on memorisation, rote learning and knowing facts devoid of context and application has been replaced with one in which mathematics has purpose and application. (Yelland & Kilderry, 2010, p. 93)

In the primary school years, especially the early years, much use is made of physical manipulatives, since this strategy is deemed to help children build solid mental representations of mathematical concepts and promote learning through hands-on play. Investigation and construction of understanding through collaboration are also common in mathematics pedagogy. ICT is changing the ways people use mathematics in everyday life and work, and this has triggered further changes in mathematics curricula and pedagogies. It is in this context that we discuss the use of ICT in primary mathematics education.

**ICT as Construction Tools**  One way in which ICT can facilitate teaching and learning of mathematics is through inquiry-based learning such as WebQuest activities, in which students practise using data and information they find from the
Internet. Halat and Peker (2011) found in their study of WebQuest that the students were able to do more mathematical activities in a game or in a story than in decontextualised practices of mathematical rules. Given that WebQuest-based applications for mathematics instruction also had a positive effect on the motivation of the pre-service elementary school teachers who participated in the study, the researchers believed that developing WebQuest-based activities would be beneficial for both teachers and students.

Tangram is a software for teaching primary geometry. Lin, Shao, Wong, Li & Niramtranon (2011) conducted a study to examine how this collaborative and manipulative virtual Tangram puzzle could assist children in learning geometry in a computer-supported collaborative learning environment, using tablet computers. Many advantages of using the puzzle were identified: (1) it enhanced the shapes rotation and spatial ability of students; (2) it improved students’ competency in spatial reasoning; (3) it increased face-to-face discussions as well as online communications among students; and (4) it boosted students’ critical thinking, confidence, and willingness to learn. In addition, teachers found it easy to summarize and explain geometrical concepts using the puzzle.

ICT as Information Tools, Tutorial Tools and Simulation Tools

There are several other ways in which ICT can facilitate mathematics teaching in primary schools. For example, robots as instructional assistants or ‘learning companions’ may enhance students’ learning motivation and performance (Barker & Ansorge, 2007). Wei, Hung, Lee and Chen (2011) demonstrated the design of a Joyful Classroom Learning System (JCLS) with flexible, mobile and joyful features. The system consisted of a robot learning companion (RLC), sensing input device, mobile computation unit, mobile display device, wireless local network and operating software. The authors found that JCLS could provide learners with more opportunities for hands-on exercises and deepen their understanding. Learning with the system also allowed students more thinking time for elaborate knowledge construction. As an assessment tool, the researchers found that JCLS supported instructors in immediately acquiring the learning status of every student and enabling them to adjust their instructional strategies and provide additional support, where needed.

Games can also be used to assist teaching primary mathematics. Chang, Wu, Weng, and Sung (2011) conducted a research in Taiwan on using games to encourage problem posing and problem solving among fifth graders (n=92). They found that students in the experimental group posed more sophisticated problems in the post-test than did the control group, who did not show as much enthusiasm for the learning activities.

Moyer, Bolyard, and Spikell (2001) discussed the possible role of ‘virtual manipulatives’. Some possible advantages include the ease of digitally recording students’ use of the manipulatives for assessment, review and discussion; the ability to provide computerised prompts and feedback; the ability to vary properties such as size, colour and shape; practicalities of not needing a variety of bulky materials such as blocks in the classroom; the ability to control or constrain children’s actions; and
the possibility of working in larger groups, around an IWB. It should be noted, however, that virtual manipulatives cannot be used as an equivalent of physical manipulatives as they foster different kinds of manipulation (and thus thinking) in children (Manches, O’Malley, & Benford, 2010). It is possible that as more tactile and sophisticated interfaces (such as touch screens) are further developed, this finding may no longer apply.

ICT may also assist children who have difficulties in mathematics. Gürbüz and Birgin (2012) carried out an experiment with 7th grade students (n=37) and concluded that computer-assisted teaching was significantly more effective than traditional methods as a means of remedying students’ misconceptions in probability concepts. This is important because students’ misconceptions are at the root of many difficulties in mathematics learning. Two kinds of software were used in the study: (1) software featuring animation and simulation to explain the probability concepts; and (2) tutorial and practice materials which provide examples and allow students to apply the knowledge and receive feedback to verify their answers.

With reference to the effectiveness of ICT in increasing students’ mathematics test scores, the research evidence is not convincing. In the USA, Wenglinsky (1998, cited in O’Dwyer, Russell, Bebel, & Seeley, 2008) found that both 4th and 8th grade students who used simulation and higher order thinking software had statistically significant better scores in high stakes standardised mathematics tests, but this association did not hold true for all software tools. Other studies have found weak or negative correlations between ICT use and mathematics achievement in tests. O’Dwyer et al., (2008) suggested that this may be explained by psychometric issues. The tests may not be capable of measuring the kinds of learning developed by the use of ICT in mathematics.

Science

Science teachers are encouraged to design learning activities that can give students opportunities to use ICT to search and analyse information from multimedia resources; synthesise, create, report, collaborate, and communicate results with peers and their communities; and investigate problems using simulations (McFarlane & Sakellariou, 2002). Luu and Freeman (2011) found that the scientific literacy of primary school students is determined by various ICT-related variables. Students with prior experience using ICT, who browse the Internet frequently and who are confident with basic ICT tasks, tend to earn higher scientific literacy scores. Therefore, it seems that appropriate use of ICT can be beneficial to students’ acquisition of science knowledge.

ICT as Information Tools

ICT can be valuable in primary science in that students can carry out research on the Internet on a variety of science topics. Murphy (2006) found that the Internet was being used in the primary classroom to gather science information and also as a means of communication. It must be noted that, for students who have reading comprehension difficulties, using the Internet to gather
information can present many difficulties, although some aspects of the Internet (such as video) may be supportive.

**ICT as Situating Tools**  ICT can facilitate the teaching and learning of science in the form of a virtual world created by multimedia. For instance, Campbell, Wang, Hsu, Duffy and Wolf (2010) discussed a case in which an Opensimulator 3D Application Server was used to highlight the vision for learning with technology in classrooms, focusing on life and earth science. The server is an open source, modular, extendable platform which can be used to create simulated three-dimensional spaces with customizable terrain, weather, and physics, for building plant populations in a virtual environment. In this environment, students are able to conveniently explore the interaction between particular traits in organisms, the genes that control those traits, and the effects of changes in the environment. They can also test hypotheses with virtual experiments and see the result within a short period of time – this is difficult, if not impossible, in traditional science classrooms.

ICT educational games provide another tool for the teaching and learning of science. Research studies indicate that a game-based learning approach might stimulate children’s abstract thinking during science activities and foster their higher order thinking ability (e.g., Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010). In Yien, Hung, Hwang, and Lin’s (2011) study, a game-based learning approach to study nutrition was used in a primary classroom. Results confirmed the positive influence of computer games on various aspects of students’ knowledge about nutrition. The students also expressed hope that game-based learning could be applied to other subjects. Similarly, Lim, Nonis, and Hedberg (2006) explored the use of a 3D multiuser virtual environment, known as Quest Atlantis (QA), in a series of primary science lessons in a Singapore school. This study provided useful lessons regarding the incorporation of QA into the primary science curriculum, such as students’ language and computer skills, classroom management issues and support from school and parents.

**NECESSARY AND SUFFICIENT CONDITIONS TO SUPPORT ICT FOR TEACHING AND LEARNING IN PRIMARY SCHOOLS**

The introduction of new technologies into any learning situation requires careful thought and planning, and a good deal of developmental testing. This process requires multidisciplinary approaches involving teachers, researchers, technologists, developers and students (Hartley, 2007). Among them, teachers play a pivotal role in creating ICT-mediated learning environments (Lim, 2007). These roles include evaluating ICT tools, assessing ICT competencies of students, setting clear expectations, negotiating objectives with students, preparing students for lessons by adopting various scaffolding strategies, and so on. For teachers to carry out these roles effectively, they need support from different elements of the context and the learning environment.
In a study of ICT integration in Singaporean schools, Lim (2007) analyzed the necessary and sufficient conditions for effective integration of ICT in the classroom and the supporting context of the school. These conditions include classroom management issues, availability of ICT tools, establishment of disciplinary and educational rules, division of labour among teachers, teacher assistants and students, and supporting school policies. In this section, we will focus on presenting these conditions in terms of policy and school leadership, physical and technological infrastructure, curriculum and assessment, and professional development.

**Policy and School Leadership**

Policy makers and school administrators need to apply strategies to address the various barriers to successful integration of ICT in the classroom and support the creation of necessary and sufficient conditions for that purpose (Lim, 2007). Tondeur et al. (2008) pointed out that school-related policies, such as an ICT plan, ICT support and ICT training have a significant effect on the use of ICT in classrooms. National policies are also needed to address various issues from creating a shared vision among school practitioners to building good physical and technological infrastructure, initiating industry-school partnerships, and providing training to teachers (Lim, 2007; Vallance, 2008). Lim (2007) proposed three policy recommendations on the national level to promote ICT integration in teaching and learning: 1) develop strategies for student ICT competency development in selected schools; 2) set ICT competency standards for teachers and students; and 3) redesign the mode of assessment and de-emphasize examination grades in order to optimize the potential of ICT for teaching and learning.

To execute national plans and government policies, school-based ICT plans and policies for learning and teaching with ICT is necessary (Gülbahar, 2007; Tondeur, van Braak, & Valcke, 2007; Vanderlinde & van Braak, 2011). Tondeur et al. (2008) revealed five areas of school level ICT policy that are key to the integration of ICT in the classroom: 1) ICT policy plan; 2) school leadership represented by the principals; 3) supporting conditions such as sufficient access to ICT facilities, skilled staff and ICT coordinators; 4) evaluation of ICT integration practices; and 5) cooperation with other schools. Lim’s (2007) recommendations for school policy stressed the importance of a shared vision by all members of the school community; learning and sharing among teachers and staff; and setting up an incentive mechanism to encourage innovative practices. Throughout the process, school leadership is a key factor that impacts ICT integration in the classroom (Tondeur et al., 2008). Yuen, Law and Wong (2003) found in their case study of ICT integration in Hong Kong schools that the leadership of schools plays a crucial part in shaping their response to ICT innovations and the degree of ICT integration in schools. School principals are especially important as they are often the one who initiate ICT plans on both strategic and action level (Tondeur et al., 2008).
Physical and Technological Infrastructure

Physical and technological infrastructure of ICT is a fundamental condition for implementing changes to using ICT in education. Setting up the necessary infrastructure requires consideration of the availability of physical infrastructure (for example, rooms for servers, computer rooms, placing of cables and network points, electricity supply points), ICT hardware and software, and human resources to set up and maintain the infrastructure and support the everyday running (Lim, Chai, & Churchill, 2010). After ensuring sufficient ICT infrastructure for both teachers and students, schools need to employ technical assistants for maintenance work and to ensure that the infrastructure adheres to the software as well as the implementation procedures (Divaharan & Lim, 2010). ICT coordinators are needed to keep schools up-to-date with new developments of ICT, decide the direction of ICT use, and organize training for teachers. Through planning, allocating resources and budget, and giving technical and curriculum support, such coordinators guide communities of teachers in the implementation of ICT-based teaching and learning (Lai & Pratt, 2004).

Both hardware and software need to be designed according to appropriate learning theories and pedagogical practices. Since different forms of ICT serve and augment different teaching and learning experiences, practitioners need to make informed judgments about which hardware and software are best for enhancing student learning in the context of the learning environment. Software needs to be chosen or developed after considering the instructional strategy. For example, CD-ROM and DVD-ROM can provide individualized instructions on using ICT, as can some drill and practice programmes. Classrooms which undergo the transition stage from being traditional to being ICT-facilitated may face many pedagogical problems, such as lack of appropriate visual examples, insufficient in-class practice, overloaded content and disordered learning sequence (Lee, 2001). Therefore, well-developed software that is motivating, organized, and interactive can help structure ICT-facilitated learning activities and allow students to learn individually outside of class.

Curriculum and Assessment

Governments, schools and teachers all play a role in facilitating the development and execution of ICT integration in the curriculum. Many countries have official policies on the use of ICT to improve the quality of education. Such policies need to be implemented through concerted plans and actions at the school level, involving school leaders, administrators and teachers. As noted by Vanderlinde and van Braak (2011), an essential condition for ICT policy implementation to be successful is good communication between educational policy officials, schools and teachers. Consistent information to schools and teachers can link broader ICT policy to local school level ICT policy (Jones, 2003). Especially when rapid changes are brought about by ICT integration in the curriculum, encouragement and support at the school level, for teaching staff, are indispensable (Divaharan & Lim, 2010). One potential
ICT IN PRIMARY EDUCATION

problem in the process of implementation is that a proposed national ICT policy and curriculum can become inconsistent with those implemented at the school level. Tondeur et al. (2007) suggested that schools should pay attention to a few key issues to avoid this problem: a) the planning of the ICT curriculum across the school; b) strategies to change or redirect educational practices; c) access to courseware for ICT integration within the curriculum; and d) opportunities for professional development of teachers and staff. Moreover, curriculum reform related to ICT is unlikely to succeed unless teachers’ personal perspectives and educational practices are understood (Niederhauser & Stoddart, 2001).

Effective use of ICT-based assessment may also play a positive role in enhancing general practices of ICT integration in the classroom. In this regard, the experiences of both teachers and students matter. A good way for implementing ICT can be based on the use of computer-based assessment tools under a specific assessment framework, agreed and practiced by teachers. The reason is that if formal assessment is carried out via computers, teachers will need to incorporate some elements of similar tasks in their teaching to prepare students adequately (McFarlane, 2001). Moreover, when students are stimulated to think about their learning process while using the assessment tools, ICT becomes learning-oriented and it becomes possible to examine students’ action and thinking process. Thus, ICT-based assessment tools can support student learning by directing them to useful resources, rephrasing important questions, and providing additional information and answers to their questions (Miller, 2009).

Professional Development

As indicated above, professional development is needed for all school staff who play a role in the process of ICT integration, but the competency of teachers is most important. Littlejohn (2002) suggested several strategies for professional development to help teachers incorporate new teaching methods with the use of ICT. Such professional development programmes 1) focus on professional development outcomes that can be evaluated; 2) provide training on educational theories with reference to ICT; 3) involve academics to assist teachers’ in planning learning activities; and 4) offer enhanced ICT skills. However, although professional development programmes are usually designed by academics, actual change starts from teachers, thus consideration of teachers’ point of view is important (Rodrigues, Marks, & Steel, 2003). Moreover, innovation in education that is not directed at actual school practices tends to fail (Fullan & Hargreaves, 1992). Thus professional development needs to be local- and context-based on specific subjects in particular schools so that the professional development offered is of intrinsic value to individual teachers (Rodrigues et al., 2003).

Research studies (e.g., Loveless, 2003; O’Rourke, 2001) suggest the importance of focusing on pedagogy rather than on technology itself, and on the need to innovate teaching styles when building teachers’ ICT in education competences. One example of such innovative teaching practice is to have teachers engage in online forums during professional development (Prestridge, 2010). This can
facilitate the development of ICT teaching communities, which can foster both critical discussion and collegiality. Teachers’ beliefs about ICT and education and their understanding of the value and purpose of ICT also play crucial roles in determining if and how teachers will use ICT in classrooms (Rodrigues et al., 2003).

CONCLUSION

ICT is finding a place in more classrooms and there is a perception among educators and policy makers that it is now a necessity in primary education if children are to become successful in the 21st century. In recent years, the uses of ICT have expanded so that they can be used as information, situating, construction and communication tools, among others. Furthermore, software, hardware and connectivity have become more sophisticated so as to allow more integration of ICT to better suit the ways in which most primary teachers teach, incorporated into subject content and collaborative work among children. In this chapter we discussed how ICT can be used in several aspects of primary education, and outlined some important and illustrative research. Although ICT can be used in powerful ways, practices in schools do not always reflect this. Educational systems and bureaucracies are often unable to adopt and execute ICT-facilitated teaching and learning; they may also lack access to the expertise necessary to set in place appropriate infrastructure and processes. To overcome this, partnerships with academics and the building of professional networks are essential. We have also pointed out that professional development should be tailored to the needs of the teacher and classroom concerned. Otherwise, teachers may use technology without changing their underlying pedagogies, and thus miss valuable opportunities to enhance children’s learning.

REFERENCES

ICT IN PRIMARY EDUCATION


LIM & OAKLEY


Law, N., & Chow, A. (2010). Teacher characteristics, contextual factors, and how these affect the pedagogical use of ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study* (pp. 181-219). ICT: Springer.


**AFFILIATIONS**

Cher Ping Lim  
*Centre for Learning, Teaching and Technology*  
*Hong Kong Institute of Education*

Grace Oakley  
*Graduate School of Education*  
*University of Western Australia*
FACTORS AFFECTING THE ICT INTEGRATION AND IMPLEMENTATION OF ONE-TO-ONE COMPUTING LEARNING ENVIRONMENT IN A PRIMARY SCHOOL – A SOCIOCULTURAL PERSPECTIVE

INTRODUCTION

This ethnographic case study describes and analyses the conditions that support the seamless integration of information communication technology (ICT) into the classroom with school initiated student one-to-one computer ownership program in a primary school from a sociocultural perspective – activity theory. The findings suggest the importance of two factors: technological infrastructures and teachers’ beliefs and practices. In addition, curriculum, school leadership and professional development also play less visible but supporting functions in the process of integrating ICT into the teaching and learning process.

BACKGROUND

This paper describes and discusses the conditions that support the seamless integration of information communication technology (ICT) into the classroom vis-à-vis the school-initiated one-to-one computer ownership program for all its Primary 4 (i.e., aged 10) students from a sociocultural activity theory perspective. The school in this case study research has implemented a one-to-one student computer ratio for all its students when they started school at Primary 1, with computers provided by the school. Starting from Primary 4, students procure and use their own computers for learning.

The school in this research study is one of the eight future schools under the FutureSchools@Singapore program. The FutureSchools@Singapore program is a collaborative project between the local educational ministry and information communication development authority. The main aim of the program is to have a small group of schools lead the way in providing possible models for the seamless and pervasive integration of information and communication technologies (ICT) into the curriculum for engaged learning in schools.

The school in this study took a progressive approach by providing the necessary computing device (i.e., notebook computers) from Primary 1 to 3. In Primary 3, the school started to discuss student one-to-one computer ownership initiative with parents. The whole cohort of 225 students and parents supported the program – 160 students purchased the school recommended notebook computer model, 50 used...
their existing computers and the remaining 15 student tapped on to the financial computer assistance scheme provided by the local infocomm authority (i.e., InfoComm Development Authority, Singapore).

ONE-TO-ONE LEARNING ENVIRONMENT

Research studies suggest that one-to-one programs are associated with increased student and teacher technology use with increased student engagement and interest (Bebell & O'Dwyer, 2010). New modes and patterns of communications via various online collaborative software applications are also evident (Oliver & Corn, 2008). The computers facilitate students in connecting the classroom to the outside world, mediating their social learning process and also contextualizing their learning experience (Liu & Milrad, 2010). Lei and Zhao (2008) also stress that the one-to-one laptops provide great opportunities and resources for teaching and learning. According to Lei and Zhao (2008), the results revealed that students used their computers or laptops for various tasks related to learning, communication, expression and exploration. Students also gained significantly in their technology proficiency.

However, the above authors (Bebell & O’Dwyer, 2010; Donovan, Green, & Hartley, 2010; Dunleavy, Dexter & Heinecke, 2007; Lei & Zhao, 2008) caution the over generalisation of the potential one-to-one programs could bring to students’ learning. Larkin and Finger (2011) highlight that despite the increased access of one-to-one, actual usage may still be limited due to individual teacher agency, a crowded curriculum and the historical use of computers. Lim, Tay and Hedberg (2011) also highlight conditions such as, the commitment of teachers, professional development, ongoing technical assistance, students’ orientation and scaffolding and adequate access to technology. Even if the issue of accessibility to technology and computers is addressed; there are other mediating factors for the successful integration of ICT into the classrooms.

CONDITIONS FOR ICT INTEGRATION

A review of the relevant research studies (Benes et al., 2008; Bouterse, Corn, & Halstead, 2009; Chere-Masopha & Bennett, 2007; Divaharan & Lim, 2010; Dourneen & Matthewman, 2009; Garthwait & Weller, 2005; Hayes, 2007; Passey, 2006; Penuel, 2006; Sipilä, 2010; Tondeur, Cooper, & Newhouse, 2010; Towndrow & Vaish, 2009) conducted in the area of ICT integration and pervasive use of technology in the classrooms suggest the importance of the following factors: (1) technological infrastructures and support; (2) teachers’ beliefs and practices; (3) curriculum; (4) school leadership and (5) professional development.

Technological infrastructure (i.e., the physical hardware such as the computing devices and the wireless network) and technical support are critical elements for successful and seamless ICT integration into the classrooms. Many researchers have ranked teachers’ beliefs and practice as one of the key factors for successful ICT integration (Chere-Masopha & Bennett, 2007; Garthwait & Weller, 2005;
Hayes, 2007; Penuel, 2006; Sipilä, 2010; Tondeur, Cooper, & Newhouse, 2010; Towndrow & Vaish, 2009). In general, curriculum refers to subject content that is developed in line with the guidelines set by the governing education body. The school leadership provides the direction and support in terms of school policy that outlines goals and also the necessary resources for the teachers. “Successful change and ICT implementation in schools depends on effective leadership” (Stuart, Mills, & Remus, 2009, p. 734). “Strong and coherent leadership was an important factor in initiating and maintaining the impetus of integration ICT” (Hayes, 2007, p. 392). Ng (2009) also reports that strong leadership is needed to promote quality ICT integration. Professional development is an essential part of every teacher’s development to improve his/her skills and knowledge. Research has suggested the importance of professional development for the integration of ICT into the curriculum (Penuel, 2006; Sipilä, 2010, Ward & Parr, 2010).

A variety of types of professional development ... are needed to meet not only the varying needs of individual teachers, but also the varying ways in which ICT can be used. (Ward & Parr, 2010, p. 113)

Classroom practices are influenced by the various factors mentioned above and the pervasive use of technology in the classrooms has to be more encompassing in perspective. The sociocultural activity theory could be used as a research framework to look into how these factors could affect the use of ICT in the classrooms.

RESEARCH FRAMEWORK-SOCIOCULTURAL ACTIVITY THEORY

Many concerns of educational theory, particularly those related to computers, can be discussed by using activity theory, which offers a flexible framework that addresses the dynamic and complex nature of educational interactions (Gilbert, 1999). Activity theory is used as a framework of analysis for this study as it provides an encompassing perspective, which looks into the sociocultural dimensions of the use of ICT in education. A brief review of the research studies that have used activity theory as a research framework is presented in this section to provide a better perspective of how this theory has been used in recent educational research studies.

Lim (2002) suggests a socio-cultural approach towards the study of technologies in education and rejects the view that this could be studied in isolation. He points out that it must be studied within the broader context in which it is situated. He argues for a more holistic approach of studying ICT in schools by adopting a socio-cultural perspective. As technologies enter the socio-cultural setting of the school, it “weaves itself into learning in many more ways than its original promoters could possibly have anticipated” (Papert, 1993, p. 53). It may trigger changes in the activities, curriculum and interpersonal relationships in the learning environment, and is reciprocally affected by the very changes in causes (Salomon, 1993).

From this perspective, ICT is a mediational tool, incorporated within learning environments with authentic goals and purposes for students, and settings
that are explicitly interpreted with other experiences of knowing and understanding as they get organised at other times. (Lim, 2002, p. 412)

Waycott, Jones, and Scanlon (2005) describe the use of the activity theory framework to analyse the ways that distance part-time learners and mobile workers have adapted and appropriated mobile devices for their activities and how their use of these new tools have in turn changed the ways in which they carry out their learning or work. They argue that there are two key strengths in using activity theory framework in their context. First, is the emphasis on the activity itself rather than, for instance, simply on the interaction between the human and the computer. The focus is on the user’s objectives and activities. The computer (or any other device) is the tool through which the user achieves his or her objectives. Next, activity theory enables analysis of an interactive dynamic process of users and their tools.

Lim, Tay, and Hedberg (2011) use activity theory as a framework to analyse the factors and conditions surrounding the introduction of a 3D game-like multi user virtual environment (MUVE) in a primary school. This study explores how a particular set of strategies and conditions might encourage and sustain the use of the MUVE within an educational setting. In addition, “activity theory has been successfully used to analyse successes, failures, and contradictions in complex situations without reductionist simplifications” (Lim, 2002, p. 413). Activity theory provides a powerful and descriptive framework that focuses around a “mediated activity system”, which comprises the individual practitioner, the colleagues and co-workers of the workplace community, the conceptual and practical tools, and the shared objects as a unified dynamic whole. (Engeström, 1992)

Lim (2002) argues for a more holistic approach of studying ICT in schools by adopting a sociocultural perspective. He proposes that research studies in ICT need to shift their attention towards the whole configuration of events, activities, contents, and interpersonal processes taking place in the context that ICT is used. Such studies are particularly critical to educational research where the object of its inquiry is not simply knowledge, but usable knowledge (p. 411) to the practitioners.

Human activity is socially bound; an individual never acts directly on or reacts directly to his/her environment but rather, the activity that is undertaken by the individual to achieve the object of the environment is mediated by cultural means and tools, and the dynamic nature of the activity. (Lim, 2007, p. 87)

Lim (2007, p. 87) suggests that activity theory could be used as the theoretical framework to provide insights into the ICT integration process in Singapore schools. He argues that activity theory (1) provides a conceptual map to the major loci among which human cognition is distributed in the learning environment, with ICT as one of the mediating tools; (2) includes other people who must be taken into
account simultaneously with the subject as constituents of the activity system; (3) proposes that activities are driven by something more robust and enduring than an individual goal-directed activity; and (4) considers the history and development of the ICT integration process.

Engeström (2001) stresses the importance of explicit identification of the contradictions in the activity system which helps practitioners to focus their efforts on the root causes of the problems, the multi-voicedness of activity systems, historicity, and the possibility of expansive transformations in an activity system. Contradictions are perceived as sources of changes and developments. Contradictions are not the same as conflicts or problems; they accumulate structural tensions within and between activity systems historically. As activities are open systems, when a new element is adopted, this often leads to contradictions with other elements within the system itself. Such contradictions create disturbances and conflicts but these could also be opportunities for innovative changes and developments.

Engeström (1992, pp. 20-22) outlines four different levels of contradictions that could appear within and between activity systems – primary, secondary, tertiary, and quaternary contradictions.

For primary contradiction, he uses the example of a general practitioner in the primary health care setting to illustrate primary contradiction of activities in capitalist socio-economic formations as the inner conflict between exchange value and use value within each element of the triangle of activity. For instance, the tools of the work of the general practitioner include many varieties of medications and drugs. But they are not only a medium for healing, they are also products with a price tag that is produced for a market and sold for a profit. Every doctor will face this contradiction in his or her daily decision making.

Secondary contradictions are those that appear between the elements within the activity system. He uses the typical example of the rigid hierarchical division of labour lagging behind and preventing the possibilities opened by advancements in the mediating tools. He again uses the example in the medical setting of a typical conflict between the traditional biomedical conceptual tools concerning the classification of diseases and correct diagnosis on one hand, and the changing nature of the objects, namely the increasingly ambivalent and complex problems and symptoms of the patients. Contradictions arise when these problems do not comply with the standards of classical diagnosis. It will require an integrated social, psychological and biomedical approach which may not yet exist.

Tertiary contradiction appears when representatives of culture introduce the object and motive of a culturally advanced form of the central activity into the dominant form of the central activity. For instance, the primary school student goes to school in order to play (the dominant motive) with his or her classmates and friends but parents and teachers try to make the student engage in academic-related activities (the culturally more advanced motive). Contradiction arises when the culturally more advanced motive is formally implemented but might be still subordinated to and resisted by the dominant form of activity.
For the quaternary contradictions, it requires us to take into consideration the significant neighbouring activities (technical infrastructure, teachers’ beliefs and practice, curriculum, school leadership and professional development) linked to the central activity which is the original object of the study. Basically, quaternary contradictions emerge between the implementation of the central activity and the neighbouring activity in their interactions and exchanges. He uses the example of a doctor working on a new holistic and integrated medical concept who suggests certain changes to a patient’s habits. The patient’s way of life is the object-activity; if the patient is merely regarded as abstract symptoms and diseases, isolated from his/her activity contexts, it will create contradictions between the central activity and the object-activity. These levels of contradictions are represented in Figure 1.

An activity system is always a community of multiple points of view, traditions, and interests. The multi-voicedness is multiplied in networks of the interacting activity systems. It is a source of trouble and a source of innovation, demanding actions of translation and negotiation. (Engeström, 2001, p. 136)

As activity systems take shape and get transformed over lengthy period of time, their problems and potentials can only be understood against their own history. History itself needs to be studied as local history of the activity and its objects and as history of the theoretical ideas and tools that have shaped the activity. (Engeström, 2001, p. 137)

The possibility of expansive transformations in activity systems is achieved when some individual participants begin to question and deviate from the established norms due to the aggravation of the contradictions of an activity system. An expansive transformation will then be realised when the object and motive of the activity are reconceptualised to take on a different and wider horizon of possibilities than in the previous mode of the activity.

In this study, activity theory as proposed by Engeström (1992) is used to organise and analyse the quaternary contradictions between the central activity and its neighbour activities. Through this process, the more systemic contradictions are identified.

The identification of contradictions in an activity system helps practitioners and administrators to focus their efforts on the root causes of problems. Such collaborative analysis and modelling is a crucial precondition for the creation of a shared vision for the expansive solution of the contradictions. (Engeström, 2000, p. 966)
An ethnographic case study design is adopted in this exploratory study (Stake, 1995). The main intent is to discuss the key factors supporting the ICT integration effort vis-à-vis the one-to-one program. The paper also describes the school’s effort and process in the implementation of the student computer ownership program, as well as its one-to-one computing learning environment initiative to date. Although ethnographic case studies seem to be a poor basis for
the purpose of generalisation to inform about future practices, the intent is not to understand other cases. The most important criterion is to maximise what we can learn from the case rather than for generalisation purposes. The implementation considerations of this school could be used to inform the education fraternity regardless of where they are situated.

The research methods include: (1) questionnaire survey and informal interviews with teachers and parents; (2) the review of students’ documents (i.e., schemes of work and lesson plans) and (3) observations by the authors. Data collection from teachers, parents and students aim to provide a more comprehensive account of the case. The data from the various research methods (i.e., questionnaire surveys, informal interviews, review of documents and observations) mentioned above are triangulated to enhance validity of the study.

KEY FINDINGS

Observations on the Conditions for One-to-One Learning and ICT Integration

The five conditions – technological infrastructures and support, teachers’ beliefs and practice, curriculum, school leadership and professional development – listed below could be conceptualised as the neighbouring activity systems to the central activity of ICT integration into teaching and learning. The description below highlights how activity theory is being used to illuminate the contradictions on the achievement of the object (i.e., the use and integration of ICT into the classrooms). Quaternary contradictions emerge between the implementation of the central activity (i.e., the use and integration of ICT into the classrooms) and the neighbouring activities (i.e., technological infrastructures and support, teachers’ beliefs and practice, curriculum, school leadership and professional development) in their interactions and exchanges.

Technological Infrastructures and Support  The ICT department worked with the teachers and also liaised with various industry representatives to set up the necessary infrastructure (e.g., wireless network). The school’s ICT team of teachers and technicians also worked with these representatives to recommend a model of computer (i.e., 13 inch, full-featured notebook computer weighing approximately 1.8 kg) with the necessary software (e.g., word-processing, presentation, spread sheets, and anti-virus), warranty and repairs, and insurance scheme for the students. The school also had a 4-man technical team to set up and assist technical requirements and troubleshooting. The serviceability of the computers and technological infrastructure directly affected the usage rate of ICT in the classrooms.

The Head of Department for ICT and the technical team discussed and consulted with the school administration over the budget, funding and ICT direction of the school. Contradictions mainly arose between the rules-object and division of labour-object, as shown as lightning-shaped arrows in Figure 2. All procurements and technical installations had to abide by the financial procedures
and technical specifications stipulated by the relevant authorities. In addition, the school administration also needed to balance the funds and budget allocated for ICT and one-to-one learning environment vis-à-vis other programs and initiatives of the school. There was always an opportunity cost as money spent in ICT would mean lesser funding for other programs. For instance, the number of technical
support personnel to employ, hardware to be purchased and number of internet access points have to be carefully considered vis-à-vis other programs and expenditures of the school. Serviceability and accessibility of ICT would be affected if there was a change to the number of technical support personnel, number of hardware available and the number of internet access points.

*Teachers’ beliefs and practice* Since teachers who are familiar with technology tend to incorporate the use of ICT into their lessons, special care was taken in the selection of teachers who would be teaching these Primary 4 classes. All the teachers were ICT savvy and have been using ICT for their administrative work, leisure, as well as teaching in the classrooms. Most of the teachers selected had good track records of ICT use in their classroom teachings so as to ensure the success of this first implementation of the program.

The pedagogical concept of learning from and with technology (Ringstaff & Kelly, 2002) guided the teachers in their planning of lessons. Broadly speaking, learning from and learning with technology could provide a very useful conceptual technological pedagogical knowledge framework when integrating ICT into teaching and learning. The act of learning from the computer leans itself more towards the behaviouristic theories of learning whereas learning with technology has its roots from the constructivist and social constructivism paradigms. More passive behaviours such as reading and listening are associated with learning from technology, while more active behaviours such as creating, writing, and updating are associated with learning with technology (Harris & Rea, 2009).

The main contradictions were between subject – tool, rules – object and division of labour – object, as shown in Figure 3 lightning-shaped arrows. Teachers needed to have relevant technological, pedagogical and content knowledge in order to integrate the use of ICT into the teaching and learning processes. The teachers’ practice was also governed by national and school curriculum and assessment. The teachers also needed to work, negotiate and be influenced by the various players (e.g., school administrators, technicians and admin support staff) in the activity system. For instance, how the teachers could effectively utilise ICT in their teaching and students’ learning would depend on the how well the technicians had maintained the computing devices and school network. The teachers also needed to abide by the curriculum that was set up.

*Curriculum* The use of ICT was explicitly spelled out in the curriculum plans and schemes of work on how ICT would be used in the classroom. Detailed lesson plans were also planned and shared by all teachers. For instance, the use of the digital storytelling approach in the teaching of languages was planned, shared and adopted by all teachers of the school. Digital storytelling is a simple and effective approach in allowing students to create their digital ‘compositions’ with digital images and also personal digital voices. Images and student’s digital narration were added to enhance the stories. Students also created pictorial graphs with the spreadsheet software application to analyse trends and patterns in their
mathematics lessons. Teachers also sourced for relevant videos and learning materials to be shared with their students in their Science lessons.

The contradictions in the curriculum activity system came from the rules, community and division of labour. The development and review of the curriculum was governed by the national curriculum and inputs from various members of the community (e.g., Principal, Vice-Principal, Heads of Departments, Teachers and etc., as shown in the figure below), as shown in Figure 4 lightning-shaped arrows.

---

*Figure 3. Teachers’ beliefs and practice activity system*
School leaders since its inception, school leaders have been actively promoting the use of ICT to all its stakeholders – parents, students, teachers, non-teaching staff, and officials from the local education ministry. Co-ordinators of the various departments (e.g., the English, mathematics, science, and ICT) have also been actively promoting the use and integration of ICT into the curriculum. The procurement and maintenance of the infrastructure hardware and computer networks have been on-going. The principal has strongly supported the allocation of necessary technological and manpower resources for the ICT department of the school. In addition, she has also led several local and overseas study trips to learn...
more from the other schools, especially with regards to the integration and use of ICT in teaching and learning.

The main contradiction in the school leadership was the balance of the demands as set up by the various players from the community. The principal has to follow the rules and guidelines as stipulated by the ministry and, at the same time, take into account the opinions of the other significant players in the activity system (as in the community and division of labour), as shown by the lightning-shaped arrows in Figure 5.

---

**Figure 5. School leadership activity system**

- **Tools:**
  - Meetings – weekly management meetings with departmental heads for directions and decisions & also weekly meetings with all staff for dissemination of decisions and information
  - Documentations & Standard Operating Procedures
  - Strategic Planning every half yearly

- **Objective:**
  - Effective management of the school – holistic education for students and conducive teaching and learning environment for all leveraging on technology

- **Outcome:**
  - Holistic education for students leveraging on the use of technology

- **Subject:**
  - Principal
  - Vice Principals

- **Community:**
  - Heads of Departments
  - Subject Heads
  - Teachers
  - Students
  - Ministry of Education
  - Parents
  - School Advisory Committee

- **Division of Labour:**
  - Heads of Departments (e.g., English, Mathematics, Science, Mother Tongue Languages, ICT and etc.)
  - Subject Heads
  - Teachers
  - Allied educators (teacher aides)
  - Admin Staff

- **Rules:**
  - National curriculum and assessment structures
  - Financial guidelines and procedures
Teachers were encouraged to attend in-service courses, seminars, and conferences (local and overseas). Teachers also shared actively in their weekly meetings on pedagogical insights and administrative/logistical requirements to enhance each other’s professional developments, especially in the area of ICT integration into the curriculum. In addition, the school also encouraged the teachers to be practitioner-researchers by looking deeper into and evaluating their own practices. Teachers would share their projects and research studies during their in-house research seminar and also at local and international conferences. A few of the teachers were also actively publishing their research articles in international refereed journals and books.

The main contradiction in the professional development activity system came more from the need to follow the training guidelines as set by the ministry and the school, as shown in Figure 6 with the lightning-shaped arrows. Budgets for courses, seminars or conferences would need to be approved and relief would need to be planned when the professional development activities were during school days. There is also a need for support by the school leadership.

From the above discussion, it appears that the technological infrastructure, teachers’ beliefs and practice, curriculum, school leadership and professional development could be seen as neighbouring activities to the central activity of ICT integration into the classrooms. The contradictions within each and every of these activity systems have impacts on the central activity. If the contradictions within the activity systems could not evolve into more workable and effective solutions, the central activity of ICT integration into the classroom would be affected. We need to be aware of possible negative effects as well. For instance, a lack of serviceability and accessibility would inevitably impede the ICT integration effort of the school.

Teacher, Students and Parents Self-Reported Questionnaire Survey

After one year of implementation, parents, students and teachers gave positive feedback on the school’s implementation of the student computer ownership and one-to-one computing learning environment programs. Parents, students, and teachers involved were asked to rate the implementation of the programs on a questionnaire survey based on a Likert-scale of 1 to 7, with 1 being ‘strongly disagree’ and 7 being ‘strongly agree’ with the questionnaire statements. Of the 169 parents who responded to the survey, an average score of 5.32 was recorded when they were asked whether the students’ computers were well-used. The 22 teachers who were directly involved gave an average score of 5.5 when they were asked to rate the success of the one-to-one program for the cohort of Primary 4 students. All students reflected that the notebook computer or their personal learning device was a useful tool for their learning.

Twenty-two teachers who were involved in the one-to-one program for the Primary 4 cohort of students took a simple survey rating the importance of each of the five factors mentioned above on a Likert-scale of 1 to 7 (1 being not important and 7 being very important). Technological infrastructure was ranked first with an
average score of 6.35, followed by teachers’ belief and practice at 6.17, curriculum at 6.00, school leadership at 5.48 and professional development at 5.30. All teachers involved tended to agree that the above factors were at least somewhat important in contributing to the success of the program.
DISCUSSIONS

The various factors – technological infrastructures and support, teachers’ beliefs and practice, curriculum, school leadership and professional development – are factors that impact one-to-one and ICT integration. From a linear regression approach, ICT integration could be seen as the following equation:

$$\text{ICT usage in class} = \beta_1 (\text{technological infrastructures & support}) + \beta_2 (\text{teachers’ beliefs & practice}) + \beta_3 (\text{curriculum}) + \beta_4 (\text{school leadership}) + \beta_5 (\text{professional development})$$

Further analysis of the activity systems and surveys from the findings seems to suggest the following relationships among the factors, as shown in Figure 7. A path analysis as shown in Figure 8 illustrates a more comprehensive relationship among the various factors mentioned, as compared to the linear relationship equation shown above. Technological infrastructures & support and teachers’ beliefs & practice are two factors that seem to be more visible from the teachers’ perspective in influencing the ICT usage in the classrooms as indicated from the survey by the teachers. However, analysis from the activity theoretical perspective highlights the other less visible factors influencing ICT usage in the classrooms. The school leadership has influence on the technological infrastructures and support, curriculum, and professional development. For instance, school leadership influences the budget and funding to be channelled to the technological infrastructures and technical support personnel to be employed. The school
leadership would have its influence on curriculum focus and professional development needs. In turn, the technological infrastructure, curriculum, and professional development have their influences on the teachers’ beliefs and practices.

From the above discussion, it is clear that the social mediators (i.e., the rules, community and division of labour) mediated the object of each and every of the five activity systems and in turn affected the central activity of ICT integration into the classroom. This in-depth analysis of the various activity systems illuminated less visible but very important factors (i.e., the curriculum, school leadership and professional development). The main object of integration of ICT into the classrooms is mediated by the above mentioned factors, although they are not explicitly visible. Metaphorically speaking, these factors were like a web on the wind – highly structured but difficult to detect unless one looks carefully (Nardi & Engeström, 1999). This discussion suggests that studies on the use of technology should not only focus on the main activity itself; the context is equally, if not more important. Research studies that look at the relationships between teachers, students, and tools are just focusing at the tip of the iceberg.

CONCLUSION

This ethnographic case study, from an activity theoretical perspective, once again highlighted the importance of taking a holistic approach towards the integration of ICT into the classrooms and curriculum (Lim, 2007). Although the questionnaire survey and informal interviews with the teachers involved in the one-to-one initiative seem to suggest that the technological infrastructures and teacher beliefs and practices are the most critical factors, the other factors (i.e., curriculum, leadership and professional development) may be less visible to the teachers but they play important and supporting roles in this endeavour, shown in Figure 7 which illustrates the path analysis and relationships among the various factors mentioned.

Even with an elaborate technological infrastructure, teaching and learning would not be possible without committed and skilful teachers who are on the ground implementing the day-to-day lessons in their respective classrooms. In addition, directions for the school leadership and channelling of the necessary resources are all critical factors to be considered. A good curriculum plan also provides the necessary structure and procedure on how to integrate ICT in a more seamless and pervasive manner.

REFERENCES


**AFFILIATIONS**

Lee Yong Tay  
Department for Research and  
Department for Information Communication Technology  
Beacon Primary School  
Singapore

Siew Khiaw Lim  
Beacon Primary School  
Singapore

Cher Ping Lim  
Centre for Learning, Teaching and Technology  
Hong Kong Institute of Education