Singapore’s Approach to Preparing New Teachers to Use Technology in the Classroom

BY INSUNG JUNG

2000
This collection of studies on the use of technology and teacher training was supported by the World Bank’s infoDev program through a grant to the Institute of International Education (IIE). The grant was initiated to take advantage of several efforts around the world in which countries are using technology to train teachers, and/or are training teachers to use technology as tools for enhancing teaching and learning. These studies are not intended to be formal evaluations, but rather to provide detailed descriptions of the various innovations and related costs, and to serve as a guide for policymakers and practitioners who may be considering using technology in their own countries to improve teaching and learning. Below are brief descriptions of each of the projects for which case studies were conducted.

**Project Descriptions**

**ARMENIA**

The Three Pomegranate Network (3PN) is aimed at using the Internet to link students in schools in Armenia with Armenian students living abroad (http://www.3noor.org/). The designers of this Network have developed clever and pedagogically-sound learning activities that engage students in collaborative online projects focused on Armenian history, culture, language and economy, while at the same time, learning important computer and Internet-related skills. Until recently, this project has not provided any structured or formal training for teachers, but has relied on the comprehensive and organized structure of the Web-based learning activities to guide teachers in its use. The project designers also have been creative in solving problems of access to the Internet, and the report contains descriptions of some of these solutions. The Three Pomegranate Network may be a useful model for other cultures in diaspora, but their high-quality learning activities may be instructive to all educators.

**BRAZIL**

Brazil’s Proinfo program provides support to States in Brazil to introduce computers and Internet connections into schools. States are responsible for providing the training and technical support to teachers in how to use this technology to enhance teaching and learning. As a result, States’ approaches to training teachers vary. The approach developed by staff in the cognitive science research laboratory (LEC) based at the Universidade Federal do Rio Grande do Sul is described in this study.

The research staff at this lab have a long history of working with computers in schools and their model of teacher training has evolved over time, even during the course of this study. The current model of teacher and trainer development is conducted over the Internet, and the most recent iteration involved up to 500 trainers, teachers and students in creating and sharing Internet-based learning activities. The researchers at LEC and collaborating universities interact with the participants online, discuss what they are doing, and provide feedback and coaching. Teachers can use the Internet to discuss their approaches with each other and even with students. The researchers feel that this process encourages reflection in teachers and helps them better understand how they learn, and how their students learn, while also getting first-hand experience in what it means to engage in collaborative, project-based learning using the Internet. Teachers look at their own problems and questions and come up with their own solutions. This model also involves creating portfolios for each teacher and learning group, which is placed on a Web site to be studied and shared by all. A number of States around Brazil are adopting the LEC model.
CHINA

In July 1987, the China Central Radio and TV University set up a teachers college (CCRTVTC) to increase teachers’ knowledge and teaching skills, and to speed up the training of practicing primary and secondary school teachers and head teachers. Satellite teacher training centers, dispersed throughout the country, work with teachers in group sessions to view and discuss the TV shows and to provide coaching and support. Between 1991 and 1998, CCRTVTC produced almost 600 hours of TV programs of continuing education for primary school teachers and 1,450 hours for secondary teachers. Between 1996 and 1997, two million teachers and one million headmasters have received support for their training through these satellite TV programs.

However, the case study conducted in three provinces reveals great disparity in the delivery of the teacher training and TV programming, and illustrates how recent trends toward a market-driven economy is exerting a powerful influence on the delivery of tertiary-level education and training.

GUINEA

Guinea’s USAID-supported project is aimed at improving teaching and learning through the use of Interactive Radio Instruction (IRI), and includes 180 hours of teacher training provided over a three-year period. The training model uses a one-week in-person workshop at the beginning of the academic year and is supplemented by 66 half-hour Interactive Radio Instructional programs aimed at students, but with instruction for teachers modeled through the IRI lessons and printed teaching guides.

SINGAPORE

Singapore’s National Institute of Education (NIE) has recently redesigned its preservice teacher training curriculum to prepare new teachers to use technology in support of teaching and learning. Each subject class (e.g., teaching of science/mathematics, etc.) includes 6-8 hours of IT integration, and a general IT course is provided entirely online. Preservice students develop a mini-computerized lesson, which is then edited, evaluated, compiled with others and distributed to schools for use by all teachers.

Faculty from the Division of Instructional Science (DIS) work with faculty in each academic area to help them to integrate IT into their courses and each academic division has a staff person responsible for serving the IT link. In addition, they have initiated a training program for IT department heads that serve in schools. The NIE is conducting research in a number of interesting areas, including exploring the pedagogical value of having students develop multimedia programs, and the use of technology as a collaborative tool.

SOUTH AFRICA

The Shoma teacher development program uses satellite TV, computer-based lessons and collaborative lesson planning to support inservice training for teachers in South Africa. Shoma was launched and is supported, in part, by MultiChoice, a satellite cable TV provider, and is an example of productive public-private partnerships. Shoma works in close collaboration with South Africa’s National and provincial Departments of Education, and designs training to support national goals and priorities. A primary focus of the training is on the Government’s new Curriculum 2005, an innovative curriculum focused on the development of selected key outcomes in student learning.

SOUTHERN AFRICA

CASCADE (Computer Assisted Curriculum Analysis, Design and Evaluation) is a comprehensive and well-researched computer-based tool designed to guide teacher resource center facilitators and/or curriculum developers through the design of exemplary science curriculum materials. It has been pilot tested in several southern African countries and was recently adopted for use by the Peace Corps in Namibia.
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Singapore's Approach to Preparing New Teachers to Use Technology in the Classroom

STUDY OVERVIEW

This report describes how Singapore’s National Institute of Education (NIE) has integrated the use of Information Technology (IT) into its preservice training program for teachers. Data was obtained through analysis of relevant government documents, observation of teacher training courses and classroom teaching by new graduates and interviews.

Background

In April 1997, Singapore’s Ministry of Education (MOE) launched the Masterplan for IT in Education to ensure that all students have the knowledge, skills and confidence to compete in a constantly changing technological environment (http://www.moe.edu.sg/iteducation/masterplan/summary.htm). The Masterplan specified three objectives with regard to teachers’ roles in accomplishing this goal: 1) to train every teacher in the use of IT for teaching, 2) to equip trainee teachers with core IT teaching skills, and 3) to involve institutions of higher learning and industry as partners with schools.

As Singapore’s only preservice teacher training institute, the NIE was entrusted with the responsibility for integrating IT into initial teacher training programs. Accordingly, the NIE developed and began implementing a new IT plan in 1998, which identified four main areas that needed change:

- the preservice curriculum;
- the physical and technological infrastructure;
- faculty and administrator development; and
- research and development in the use of IT in education.

Objectives of Case Study

This case study describes the NIE’s efforts to design and implement an effective program for training new teachers to use IT in their teaching, and is followed by concrete recommendations to guide policymakers in other countries that may be considering introducing the use of IT into the teaching/learning process. The main questions addressed by this study are:

- What IT changes and innovations were introduced in Singapore’s preservice teacher training?
- How have the innovations been carried out?
- How do the actors in the implementation process perceive the innovations?
- What are the added costs incurred?
- How have innovations influenced the pedagogical framework, teaching methods, skills, and culture of the training institute?
- Have the innovations contributed to improvements in classroom teaching?
- What policy recommendations can be drawn from this analysis?

Methodology

Methods used to conduct the case study include: (1) analysis of NIE and Singapore official documents and Web sites, (2) individual interviews and focus group meetings with government officials, NIE faculty and students, and school principals and teachers, and (3) observations of NIE’s IT-integrated preservice teacher training courses and computer labs in primary and secondary schools.

Two visits to Singapore were made to collect data for this study, the first between 9-13 May 1999 and the second between 8-15 February 2000. Table 1 shows the number of interviews, observations, and school visits.

Instruments for the interviews and observations, developed by the researcher, were reviewed and revised based on feedback from experts in teacher training and education technology. The instrument for classroom observation was developed by analyzing the goals of NIE’s IT plan, formulating critical indicators for achievement of those goals, and creating specific observation measures based on those indicators. All classes observed were videotaped and later

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1In Singapore IT refers to advanced information technologies such as computers and the Internet.
digitized to support further analysis of the teaching and learning processes.

Because this is a case study and not an evaluation, application to other contexts should be made with caution. In addition, since the innovations have been implemented for only one year, only tentative conclusions can be made regarding their impact. Nevertheless, findings of this study may be useful for countries and agencies planning to integrate IT into classrooms and teacher preparation programs.

Table 1: Number of Interviews, Observations and School Visits for the Study

<table>
<thead>
<tr>
<th>Method</th>
<th>Institution/Number of Respondent</th>
</tr>
</thead>
</table>
| 1. Interviews  | **MOE** 2 officials  
                 | **NIE** 1 Associate Dean  
                 | 3 IT sub-deans  
                 | 1 Head, Center for IT in education  
                 | 1 Head, Department of Instructional Science  
                 | 5 faculty members including one IT specialist  
                 | 3 NIE students in practicum  
                 | 15 NIE students (a group interview)  
                 | **School** 3 principals  
                 | 3 IT Heads  
                 | 8 teachers  
                 | **Total** 45 staff |
| 2. Observations| **NIE** 2 IT foundation classes  
                 | Primary: 3 classes  
                 | Secondary: 2 classes  
                 | **Total** 7 classes |
| 3. Site visits | **NIE** Primary: 3 schools  
                 | Secondary: 2 schools  
                 | **Total** 6 institutions |
EDUCATION IN SINGAPORE

Unlike most other countries in Asia, Singapore is not a developing country. With a population of only 3.7 million and land mass of 649 sq. km., Singapore’s GDP and per capita GNP were US$85 billion and US$28,600, respectively, in 1999. The same year, Singapore’s literacy rate among residents aged 15 and over was 93.5%, and among residents aged 6-23 years, the gross enrollment ratio for primary, secondary, and tertiary levels 76.8%. The number of schools and enrollment by level is provided in Table 2.

Education is a high priority in Singapore and receives more government spending than any other sector except national security (Table 3). Application of human capital theory has led to a heavy emphasis on vocational and technical training as a means of bringing economic growth and increasing personal income (Fong and Lim, 1997). Since independence in 1965, the government has oriented education towards economic development goals (Gopinathan, 1997). The focus in the 1960s was on the provision of mass education; and in the 1970s, strong links were established between schools and industry, and school curricula were diversified and expanded to provide a wider range of occupational opportunities. Efforts were also made to equip each school with library facilities and audio-visual materials to upgrade teaching and learning resources in schools.

Reform efforts in the 1980s reflected priorities articulated in the national Goh Report (Kwong, Peck, & Chin, 1997), which called for a balanced curriculum that emphasized “Education for Good Citizenship” and “Being and Becoming” courses. Tertiary initiatives included expansion of research and development, personnel and facilities, an increase in the number of Master’s and Ph.D. programs, establishment of independent schools, conversion of double-session schools into single-session schools, and development of a comprehensive program for training and upgrading the workforce in Singapore, including teachers.

| Table 2: Number of Schools, Enrollment and Pupil-Teacher Ratio by Level (1999) |
|-----------------|-----------------|-----------------|
| Primary         | 195             | 300,153         | 25              |
| Secondary       | 148             | 173,007         | 19              |
| Combined        | 4               |                 |                 |
| Junior Colleges | 14              | 23,915          |                 |
| Centralized Institute | 2       | 1,117          |                 |
| Polytechnic Institute of Technical Education | 4 + 1 | 62,542 |                 |
| University      | 3               | 32,109          |                 |

| Table 3: Government Expenditures on Education |
|----------------|----------------|----------------|
| Proportion     | 28.9%          | 23.2%          | 24.5%          |

In the 1990s, attention was given to the refinement of school curricula and improvement of the teacher training system. Efforts have been made to balance the curriculum to nurture the whole child as an individual and as a citizen. In 1991, the Institute of Education and the College of Physical Education were merged, establishing the NIE as an independent institute of Nanyang Technological University (NTU).

In 1998, a committee comprised of senior MOE officials and NIE staff assessed whether Singapore’s teacher training system was meeting the needs of an information society, in order to support the new national vision of “Thinking Schools, Learning Nation”. The committee recommended that teacher training become more outcome-oriented, that the school curriculum incorporate IT, and that teacher training address pedagogical issues related to IT use in schools. The report also specified the need for effective use of IT in NIE’s preservice teacher training to provide new teachers with model methods of teaching.

Since its establishment as Singapore’s only teacher training institute in July 1991, NIE has provided preservice and inservice training for primary and secondary school teachers in the fields of education, physical education, arts and sciences.

It is governed by a council that consists of the permanent secretary of the MOE as chair, and other members from the MOE, NTU, NIE and related institutions (Figure 1). A director manages the Institute, which consists of four schools⁴, a head of administration, three centers (Educational Research, Computer Services, and IT in Education) and a library. The administration has four divisions: development and estate, personnel and general affairs, finance, and student affairs. Academic staff include six professors, 100 associate professors, 121 assistant professors, and 60 lecturers. The 1998/99 annual budget for operating expenses (salary, equipment, materials, etc.) was US$35.8 million.

The Institute offers a variety of courses and programs leading to a range of qualifications, from diplomas to bachelor degrees to postgraduate degrees in education. The initial teacher-training programs offered are:

- a four-year program leading to either a Bachelor of Arts or Bachelor of Science with a Diploma in Education,
- a two-year program leading to a Diploma in Education for high school graduates who will teach at the primary level, and
- a one-year program leading to a Postgraduate Diploma in Education for those with a university degree who will teach at either the primary or secondary levels.

The curriculum for all initial teacher training programs consists of academic studies (subject content), curriculum studies (teaching methods for academic subjects), educational studies, field experience and personal development. The educational studies modules provide instruction in the foundations of education (such as the history of educational development, educational psychology, classroom management, and instructional technology) while field experience refers to the teaching practicum and related forms of school-based experience.

Compared to the systems of other countries, the preservice teacher training system in Singapore is unique in several ways

- The NIE is the only formal teacher training institution in the country and is funded and regulated by the Ministry of Education. While teacher training is centralized and directly governed by the MOE, partnership between the two entities creates flexible teacher training policies and more efficient implementation of those policies.
- The NIE accepts student teachers hired by the MOE. That is, the MOE hires future teachers based on academic records, English Proficiency Tests, and interviews, then supports their training at the NIE. NIE then trains the teachers for the MOE. During training, the MOE pays trainees’ salaries, including the minimal tuition fees. Those trained must teach at least three years or pay back the salary received during training.

³There are now 12 academic groups and four in education, namely, Psychological Studies, Special Education, Policy and Management, and Education Studies and Instructional Science.
The NIE works closely with the MOE in making educational plans, developing curricula, and implementing training strategies, which means that the government’s educational policies are reflected in the teacher training system.

Education and teacher training are top priorities in Singapore. The government’s recurrent expenditure on teacher training has increased from US$9.6 million in 1987 to US$35.8 million in 1998. All NIE staff interviewed for this study reported that once a plan is established for a particular program, money is not an issue.

These features of Singapore’s teacher training system have been important in the NIE’s planning and implementation of IT teacher training. Close collaboration between the MOE and the NIE ensures that the plan reflects national visions and helps secure the budget needed for implementation. The budget was allocated by the MOE as a special development fund: US$9.1 million was allocated for 1998 – 2000, and another US$4.8 million added when the NIE moved to a new campus in 2000. US$24.2 million will be allocated to implement the plan for 2001 to 2003.
DEVELOPING THE NIE IT PLAN

The Masterplan for IT in Education, issued in 1997, is considered to be “the most significant development” and a major engine of change in promoting the use of IT for education (Williams & Wong, 1999). It specifies plans along four dimensions: curriculum revision, faculty and teacher development, physical and technological infrastructure, and research and development. The following strategies in the Masterplan are expected to have a significant impact on teaching and learning in schools.

- **Computers for teachers.** The MOE has granted subsidies for each teacher to purchase a personal computer.

- **Computers for students.** The target for 2002 is a student-computer ratio of at most 2:1. Additionally, notebook computers will be widely deployed to teachers and students.

- **IT training.** By the end of 2000, all teachers will be trained to use IT in their teaching.

- **School-Industry Partnership Scheme.** Institutions of higher learning and industry will serve as partners with schools to produce innovative and effective educational programs and projects.

- **School IT coordinator.** Each school within NIE has been allocated a new position for coordinating IT efforts, purchasing hardware and software, handling in-house teacher training and providing technical support.

- **Broadband connectivity.** A high-speed, island-wide broadband network, called Singapore ONE has been installed to eliminate data traffic jams experienced by most dial-up Internet users. All schools will be connected to Singapore ONE.

In response to the goals specified in the Masterplan, the NIE developed an IT plan for preservice teacher training. Three potential outcomes are specified in the NIE’s plan: increasing productivity, enhancing teaching, and expanding learning (See Table 4).

The NIE IT Committee developed a conceptual model to illustrate the relationships among the relevant groups and functions (Figure 2). In this model, the NIE creates an IT–integrated teaching and learning environment that allows faculty to facilitate and manage learning with various forms of IT-mediated systems. The model supports student teachers in constructing knowledge and developing skills through collaborative, interactive, and individualized learning using various technologies.

### Preservice Curriculum Revision

The curriculum was revised to provide student teachers with appropriate IT skills, and to allow them to experience learning in an IT–integrated environment. Curriculum revision was considered in the broader context of Singapore’s emphasis on developing students’ creative and critical-thinking abilities.

The curriculum now includes a compulsory 30-hour module on instructional technology as well as 6 to 12 hours of IT integration in each curricular subject. Inservice and postgraduate programs are being reviewed to explore the possibility of being delivered online over Singapore ONE.

At the primary and secondary school level, the IT plan allocates increasing amounts of curriculum time to IT-based instruction: 1% in 1999, 10% in 2000, and 20% in 2001.

### Faculty Development

The IT plan provides for training of all academic staff in basic IT use, skills to integrate technology into the curriculum, and expertise to support student teachers. Key strategies include:

- providing all academic staff with ongoing IT training and 24-hour technical support;
Table 4: Outcomes and Objectives of the NIE IT Plan

<table>
<thead>
<tr>
<th>Major Outcomes</th>
<th>Specific Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase Productivity</td>
<td>• Develop resource database and software</td>
</tr>
<tr>
<td></td>
<td>• Improve communication infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Increase access to administrative database and tools</td>
</tr>
<tr>
<td>Enhance Teaching</td>
<td>• Empower academic staff as facilitators</td>
</tr>
<tr>
<td></td>
<td>• Develop software tools for teaching support</td>
</tr>
<tr>
<td></td>
<td>• Create computer-managed system</td>
</tr>
<tr>
<td>Expand Learning</td>
<td>• Create IT-integrated environment for:</td>
</tr>
<tr>
<td></td>
<td>• collaborative learning</td>
</tr>
<tr>
<td></td>
<td>• interdisciplinary learning</td>
</tr>
<tr>
<td></td>
<td>• individualized learning</td>
</tr>
</tbody>
</table>

Figure 2: Conceptual Model for IT-Integrated Teacher Training
using IT specialists in the academic divisions to conduct training;

- creating computer-based programs for self-instruction;

- providing technical and administrative support for instructional development using IT; and

- establishing an NIE unit to help develop computer-based curriculum resources.

IT competencies for academic staff (and teachers) were specified according to three skill levels (Williams and Wong 1999). Level 1 includes acquiring basic IT skills, methods and tools for education and training purposes; Level 2 requires applying and adapting these tools; and Level 3 involves creating new techniques, methods and tools (see Tables 1-3, Appendix A). Table 5 summarizes the staff training targets in relation to the competency levels.

Physical And Technological Infrastructure

An IT-integrated educational environment must integrate instructional technologies into administration, assessment, data manipulation, development of and access to learning resources, programming, publishing and research. To meet this need, the physical and technological infrastructure proposed for NIE’s new campus includes:

- a state-of-the-art networked computer system;

- at least one network connection point in every room and common study area;

- IT-ready teaching facilities, such as lecture theatres equipped with a media projection system and Internet connection, and tutorial rooms equipped with at least an LCD projection system and Internet connection;

- a student-computer ratio of 5:1; and

- a multimedia desktop computer for each lecturer and administrative staff member.

A cable networking system will be complemented by a wireless networking system by the academic year 2003-2004, which will allow users to access the Internet from anywhere on campus. All students are expected to have personal notebook computers by 2003-2004.

Research and Development

NIE is determined to become an internationally-renowned center for applied and strategic IT research and development, and a hub for related intellectual exchange. Key implementation strategies include:

- encouraging faculty to conduct IT-related research;

- creating innovative IT-mediated pedagogies and software tools for education and teacher training;

- encouraging and supporting inter-division and schoolwide research studies within NIE, NTU and in collaboration with external IT organizations;

- establishing state-of-the-art technology rooms to demonstrate research prototypes and use of IT-mediated pedagogies; and

- developing a national center for research and development in instructional science and technology.

Each school within the Institute is expected to examine its research strengths with regard to IT and collaborate with researchers from other schools in the development of multidisciplinary research projects. Case studies on application of IT in education are initially encouraged. Later, research efforts will address creation of innovative IT-mediated pedagogies and software tools. Collaboration with outside research and education institutions is strongly encouraged.
Table 5: Training Targets for Academic Staff

<table>
<thead>
<tr>
<th>Skill Level</th>
<th>Percent of Academic Staff Trained to Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
</tr>
<tr>
<td>Level 1 - Adopt</td>
<td>90+</td>
</tr>
<tr>
<td>Level 2 - Apply and Adapt</td>
<td>10</td>
</tr>
<tr>
<td>Level 3 - Create</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 3: NIE’s Approaches to Training Teachers to Use IT
IMPLEMENTING THE NIE IT PLAN

Curriculum Revision

There are four kinds of IT courses for student teachers: a basic IT skill workshop, a 30-hour IT foundation course, a 26-hour elective course, and the 6 to 12 hours of IT integration into each curricular subject class.

▪ Basic IT skill workshops, paid for by students, are provided by external organizations and cover word processing, PowerPoint, Internet literacy, and other technical skills.

▪ A 26-hour elective course is provided by the Division of Instructional Sciences (DIS) under the course name “Message Design and Computer-Based Instruction”. The course covers the design and production of computer-based instruction.

▪ A 30-hour IT foundation course is offered by the DIS entitled “Instructional Technology”. According to the course description, it covers: “learning, thinking and the effective use of instructional technologies in the classroom; instructional planning models; selecting, creating, evaluating, and integrating instructional technologies and resource materials; promoting creativity and complex thinking through IT project work activities; and organizing and managing instructional activities with appropriate IT resources in the classroom.”

Student teachers in the course are expected to prepare computer-based micro lessons. At the end of the course, the better lessons are selected, edited and published as an interactive CD-ROM and distributed to schools for use by teachers.

NIE students pursuing a Diploma in Education must also have five weeks of practicum during the first year of their preservice training and ten weeks during the second. Those in the one-year program have a one-week practicum during their first semester and ten weeks during the second.

The practicum is based on a partnership model—NIE and the trainee’s school share the responsibility for improving trainee performance. Schools have a strong incentive to provide trainees with good support and guidance, since they often hire the same trainees when the practicum is completed.

During the practicum, NIE students observe experienced teachers for two weeks, then teach a class under supervision, eventually moving on to independent teaching. The trainee is expected to use IT while teaching, depending on the school’s IT infrastructure. The most frequently used technologies thus far are overhead transparencies and PowerPoint presentations. Student performance during the practicum, including the use of IT in teaching, is evaluated by the school using an assessment form developed by the NIE (see Appendix B). Figure 3 represents NIE’s multiple approaches to training teachers to use IT.

Faculty Development

NIE’s initial focus was on faculty development. An earlier model, in which external companies trained faculty in various computer applications, was found to be ineffective. Although external workshops have continued for faculty who lack basic IT skills, this is now supplemented by specially-trained staff who are available to provide immediate help when needed. IT specialists were recruited internally or externally for each division to help set IT training objectives, provide workshops, and evaluate IT implementation. A checklist was developed by the Division of Instructional Science (DIS) to help faculty and staff evaluate their competence in IT skills, and serves as a guide for assistance from IT specialists (See Appendix C).

To signal that IT integration is a high priority for the Institute, a sub-dean position was also established for each of NIE’s schools. The sub-dean is responsible for staff training in IT, managing IT specialists, budgeting for software purchases, and participating in policy decisions regarding IT use in teaching. The sub-dean has the authority to evaluate faculty IT use and assign bonus points on faculty evaluations for IT integration within teaching.

In the new approach, each NIE school is responsible for training its own faculty, although most workshops are centrally organized. Interviews with the sub-deans from the schools of Arts, Education, and Science revealed that each school adopts training methods according to objectives and needs of its own faculty. Seven types of faculty IT training are being tried:
1. Workshops provided by external companies.

2. Workshops provided by sub-deans or IT specialists.

3. Help from the new Center for IT in Education (CITE) and from DIS. CITE provides technical help to faculty in all schools; DIS provides training in IT use for teaching, supports IT specialists in the academic areas, develops checklists to evaluate IT use in teaching, and conducts IT-related research and development projects.

4. IT sharing during lunch hours. This is preferred by faculty, who report being too busy to attend workshops. Every month or two during the lunch hour, IT sessions are held in a computer lab and one or two faculty teach a particular skill. At the beginning about 20-25% of the faculty participated, but attendance has dropped to about 10% as their skills improve.

5. Internet resources. There is a menu within the school homepage that provides resources for faculty, such as sample lesson plans and IT-related articles.

6. A buddy system. IT specialists or sub-deans provide help at the request of individual faculty, usually focused on pedagogical issues.

7. Division newsletters. Some divisions publish newsletters to report on recent developments in IT and its use in teaching.

In 1999, CITE was established within the NIE to integrate all activities of the IT committees and divisions. Specific objectives include: establishing facilities and tools to support teaching and learning; undertaking research and development on innovative applications of IT in education; providing IT assistance and training to academic staff; and providing professional consultation and services in multimedia production and IT applications. The Center has 24 faculty and five administrative units: administration and services, multimedia production, software development, system support, and research and development.

CITE is now developing a Digital Media Repository (DMR) and video network services, exploring wireless and mobile technologies for education, and developing tools for project cooperation among student teachers and staff. Experiments in virtual reality, distance learning courses and innovative assessment systems are on the list of future projects. The CITE budget over the next three years includes approximately US$1.8 million for staff and consultants, about US$205,000 for software, US$470,000 for training NIE students, and about US$3.2 million for hardware, network and systems software.

**Physical and Technological Infrastructure**

The NIE’s efforts have focused on building a learning environment that integrates instructional technologies into all aspects of the system. Fifteen computer labs, each consisting of about 20 computers, a printer, and presentation facilities have been established to serve the 2,000 NIE students and staff. All computers are connected to the Internet and all mainframe, mini-computer, information servers, workstations, printers and a Web server are integrated. Each lab has specialized software and maintains a database of software titles. Four technicians are assigned to the computer labs to provide technical support to users.

Various digital machines have been installed, such as a VAX 4500 and an Alpha 2100 mini-computer, to support academic computing and administrative functions, and a library software program called ATLAS allows schools to gain access to the NIE library facility through the Internet. All staff and students are entitled to an e-mail account in the host system. Campus computing facilities are distributed to every user desk through the OpticFiber Network Infrastructure.

**Research and Development**

In accordance with NIE’s priority for applied and strategic research in instructional science and technology, several research projects have been conducted in each school within the Institute. The School of Education and CITE have played a major role in these projects. Studies underway in the School of Education include:

- Micro-lessons that integrate IT into classroom instruction;
- IT for personal creativity: a knowledge elicitation systems approach for enhancing the individual’s
learning capability through action research;
- A pedagogic evaluation of the EduPAD project; and
- The Teaching Practice Discourse and Computer Communications Technology Project.

One interesting research project aims to deliver an online virtual physical education lesson for every secondary and junior college student in Singapore. Through the Web, students will be able to access their own personal physical activity file and preview upcoming lessons.

Major projects led by CITE include:
- A multimedia presentation that explains the Aeroponics System, its usefulness in teaching and education, and its commercial potential;
- The Student Feedback on Teaching System, designed to help NIE students offer feedback on training courses via computer;
- The NTU Millennium Celebration Project, to demonstrate NIE capabilities in online interactive courses or lessons;
- The Physics Web Learning Project, to create an online learning environment for all students taking physics modules;
- The Online Course Development project, to create online lessons for academic staff to apply their teaching and learning strategies using Web-based lessons; and
- A pilot project for an online interdisciplinary collaborative learning system, to develop a Web-mediated learning environment for better comprehension of subjects, creative thinking, and collaborative problem solving.

Projects in the School of Science include:
- A Web-Based Resource Center for and by the Mathematics Teachers of Singapore;
- Computer Simulations of Defects and Defect Processes in Semiconductors;
- Enhancement of Teaching Strategies Using Visualization Techniques in Science Education; and
- Computational Problem Solving in Physics: Integrating Neo-Piagetian and Learning Environment Research.

Interdisciplinary projects have been encouraged. One such project, entitled “Information Technology-Based Science and Mathematics Education Through the Network,” represents applied information technology to science and mathematics education. It will develop a prototype for an interactive multimedia teaching system (IMTS) that promotes active, independent and self-paced learning. The project will also examine the use of the Internet to disseminate timely information, deliver science and math curricula, and allow exchanges of information on science and math education. Faculty from Physics, Mathematics, Biology, and Instructional Science are participating in this project.

Cost Issues

Singapore’s efforts to integrate technology into both the preservice teacher training program and K-12 schools is quite comprehensive, and considerable resources are in place to support these efforts. Today, NIE maintains approximately 800 computer terminals and 4,000 Internet ports for 1,000 staff and 4,000 students. The total value of hardware including computers, servers, and other peripherals is about $9.1 million. Internet ports, including connectivity charges, cost about $364,000 a year, at $90 per port. NIE also has invested considerably in software, which has an approximate value of $1.2 million. Seventy staff members have been hired to support and maintain this infrastructure. Technical staff are each paid $36,400 per year, for a total cost of $ 2.5 million.

The financial value of resources presented in this section were provided by NIE representatives in Singapore dollars, and converted to US dollars using the exchange rate of US$1 = S$1.65.
**Preparing NIE Facilities.** NIE invested in the renovation of facilities for a technology-rich environment. Selected rooms were designated as computer laboratories and server rooms. Air conditioners were also installed. These renovations cost approximately $152,000, but have been kept to a minimum due to the planned move of NIE to a new facility.

**Preparing NIE Faculty.** Faculty training has become an implicit function of the technology department. Most faculty already had basic technology competency, defined as their ability to use word-processing, spreadsheets and e-mail. Approximately 10-15% of the faculty needed additional help. No formal training program or budget was devoted to supporting these faculty. Instead, an informal program of peer tutoring, help sessions, and general technical support were offered. This has met the needs of most, although a few faculty members are reported to have some continuing learning needs. Similarly, there is no formal budget to assist faculty with the integration of technology into their curriculum. About $303,000 is allocated to staff whose task is to informally assist professors as part of their job description.

When faculty become interested in developing additional technology competencies, NIE contracts with an outside organization for workshops. These have tended to center around specific software applications. IT workshops have included advanced training in Excel, Microsoft’s PowerPoint, Adobe’s Photoshop, and various Web-related programs like Microsoft’s FrontPage and Macromedia’s Authorware. NIE maintains a budget of $455,000 over three years, or $152,000 per year, for these purposes.

**Preparing NIE Students.** Students are expected to use computers in their ongoing activities for homework, research, and communication. In addition, all students must pass a compulsory foundation course that addresses basic IT skills, and may choose from among 6 elective courses. Courses that address how to teach a particular subject matter (e.g., how to teach mathematics or social studies) also devote 10 hours of class time to teaching student-teachers how to integrate IT into these subjects.

Although not directly related to technology integration, NIE has also reduced the student-tutor ratio in teaching courses from 25 students per tutor to 20 students per tutor. No cost has been estimated for this increase in student support since it is not a necessary bi-product of technology integration.

**Summary.** NIE has invested resources to meet its commitment to integrate technology into the pre-service teacher training program. Table 6 summarizes the above estimates in initial technology-related investments. NIE’s technology program also requires ongoing expenditures summarized in Table 7.

It also may be helpful to view these totals in either per computer or per student estimates. Ongoing, recurrent expenditures are estimated at about $3,800 per computer and about $600 per user (1,000 staff and 4,000 students).

<table>
<thead>
<tr>
<th>Investment Type</th>
<th>Investment Amount (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities Renovation</td>
<td>152,000</td>
</tr>
<tr>
<td>Hardware</td>
<td>9,100,000</td>
</tr>
<tr>
<td>Software</td>
<td>1,200,000</td>
</tr>
<tr>
<td><strong>Total Investment</strong></td>
<td><strong>10,452,000</strong></td>
</tr>
</tbody>
</table>
### Table 7: Summary of Ongoing Technology Expenditures

<table>
<thead>
<tr>
<th>Expenditure Category</th>
<th>Annual Expenditure (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Training</td>
<td>152,000 ($152 per staff member)</td>
</tr>
<tr>
<td>Support and Maintenance</td>
<td>2,500,000 ($3,000 per computer)</td>
</tr>
<tr>
<td>Internet Ports</td>
<td>364,000 ($90 per port)</td>
</tr>
</tbody>
</table>

*Total Annual Expenditure* | $3,016,000*

*Annual totals do not include either the 10 hours of class-time per course or the cost of supplies for which no estimates were available.
EVALUATION OF IMPACT

In the following section the impact of the integration of IT into the preservice program will be discussed as it relates to the NIE faculty, the curriculum, NIE students and classroom teaching.

NIE Faculty Attitudes and Application of IT

Interviews with eleven faculty revealed a general increase in faculty interest in and use of IT, as well as several concerns. All agreed that faculty have become more positive in their attitude toward the use of IT in teaching, as well as more active users. One example is the increased use of the Internet in disseminating curriculum. In May 1999, there were no courses at NIE available in their entirety on the Web, but just one year later, between 50% and 70% of the faculty had used the Web in their teaching. NIE has purchased a commercial software program called “Blackboard Course Info” to help faculty develop and deliver Web-based courses. Another example is the faculty’s interest and success in publishing electronic books to help teachers use IT in their teaching. Additional publications are now planned following positive teacher response to the books.

Faculty cited a new training approach as one reason for the positive attitudes toward use of IT in teaching. Under the new approach, the NIE first forms innovative groups with a small number of enthusiastic people, such as sub-deans and IT specialists, who then encourage others and in doing so, build a critical mass of users and believers. Faculty also found the technology to be more user-friendly than in the past. Availability of on-demand resources and technical support was cited as a third driving force behind recent successes. Several faculty especially welcomed the support provided by CITE and training by IT specialists or sub-deans.

The two problems most commonly reported were bifurcation between older and younger faculty regarding IT, and difficulty balancing time between subject areas and IT. All sub-deans and the head of CITE are junior faculty in their 30s and have been using IT for several years. Yet older faculty, despite their valued experience and expertise in other teaching aspects, tend to be less familiar with new technologies and some are more resistant to IT use. Faculty and IT specialists are also stretched between their subject-related research and IT work; given time constraints, most prefer teaching or research in the subject discipline rather than learning and integrating new IT skills. It was suggested that real behavioral change on the part of everyone may simply take time.

IT specialists felt the brunt of both issues, facing reluctance on the part of some faculty and insufficient time for research in their own subjects. They found the official workload reduction and IT recognition on faculty evaluations to be insufficient incentive for their additional responsibilities.

Regarding applied research and development efforts at the NIE, all faculty interviewed agreed that IT-related research activities have been moving slowly and so far focus only on development, quick implementation, and short-term impact. Citing a shortage of evidence that IT helps teaching and learning, they suggested that new studies address cost-effectiveness and moral issues regarding the use of IT in teaching.

Retention and recruitment of IT-trained faculty and staff is another problem facing the implementation process. NIE salaries are not competitive with those of the private sector, making recruitment difficult in the strong economy. NIE developed faculty with skills, only to lose some to competitors. A more flexible, self-managed funding system was recommended by the head of CITE.

IT in the NIE Curriculum

Interviews with NIE faculty and students revealed that IT has been integrated successfully into methods courses, and the IT foundation course and elective courses provide basic IT skills to students. However, IT integration into academic subjects was rated unsatisfactory by most interviewees. The extent of IT integration also was reported to vary across schools. For example, faculty in the School of Education were more likely to provide student-centered instruction and accomplish IT integration than were faculty in other schools. Overall, decision makers indicated that progress in IT integration has not been as strong as they had hoped, so that closer monitoring by sub-deans and IT specialists is now necessary.

Unfortunately, I was not able to observe IT-integrated courses in methods or subjects at NIE due to the timing of the site visits.
In order to better assess the use of IT in the NIE curriculum, tutorial sessions of two IT foundation courses were observed by the researcher, one in May 1999, and the other in February 2000. The 30-hour course comprises perhaps the greatest effort to impart IT skills to teachers for use in the curriculum. The course meets for three hours a week for ten weeks, with one hour dedicated to lecture and two to tutorials, which includes individual consultations, presentations, group discussion, and feedback. Student evaluation is based in part on a final project, the creation of a micro-lesson to be done in pairs. Here, student teachers use IT to create a lesson focusing on one or two learning objectives that match the school curriculum. In observing these courses, the researcher specifically looked for ways the courses did or did not meet the goals of the NIE IT plan.

Each tutorial session had 20 students and was conducted in one of the multimedia computer labs at NIE. The labs had 20 Internet-connected computers for student use, one computer connected to a beam projector for presentation, and one printer. Consistent with goals of the NIE plan, the students were encouraged to integrate IT in developing a lesson of their choice using various learning resources. The students observed were able to make effective use of IT in their presentations. PowerPoint presentations with Web links were the most widely used technology. Printed materials and overhead transparencies were also in use. Some students even created Web sites for their presentations.

The NIE plan also states that instructors in IT-integrated courses should play a role of facilitator and try to customize instruction to fit individual needs and abilities of students. During one tutorial session observed, nine groups of students made presentations on the analysis of various learning resources for a selected topic, with each presentation moving quickly and lasting between five and ten minutes. The instructor spent ten minutes for lecture on the technical, aesthetic, and pedagogical design aspects of student projects. He then answered questions and provided feedback on the presentations, often through comments delivered to an individual or small group. He frequently asked leading questions such as, “What do you hope students will learn from that?” or “What are you trying to achieve from these Web sites?” The instructor thus appeared to be succeeding in playing a facilitator role.

In addition, IT-integrated courses are expected to provide opportunities for active, collaborative, and interdisciplinary learning. This goal also appeared to be met. During the second tutorial observed, the ambiance was lively, with students working in pairs, developing their lesson plans for the class project, discussing objectives, checking Web sites, and writing up the results of their discussions. Here too, the instructor moved around the classroom and provided individual consultation. Students asked for help when needed and seemed to be enjoying themselves.

When interviewed about the new curriculum, students all agreed that the foundation course provided useful pedagogical strategies for the use of IT in classroom teaching. In particular, students appreciated being able to download basic information and materials from the Internet. However, they reported that the 30 hours of instruction was not enough time to gain IT proficiency, and some wanted more IT integration in the practicum. The professor suggested that students would gain more from the class if use of PowerPoint and Web page development had been prerequisites.

One of the most significant developments for IT use in schools is sharing of quality micro-lessons with classroom teachers. As detailed in the IT integration plan, in 1998 and 1999 the best multimedia assignments were recorded on CD-ROM for distribution to schools as supporting teaching material. While the program was initially funded by the NIE, DIS has since hired a private company to develop and distribute the CD-ROMs. The company funds production while NIE provides the content, and profits are shared by the two entities. Through a Web site designed by the company, the best micro-lessons produced by student teachers at NIE are available to teachers and the public at a low cost.

NIE Student Attitudes and Application of IT

IT mastery by NIE students can be described using the list of IT competencies outlined by Williams and Wong, and categorized into three stages (see Appendix A). In the acquisition stage, student teachers acquire basic IT skills and become comfortable using IT tools and terminology. In the application stage, they are able to select and evaluate IT-based resources and integrate IT into their classes. In the innovation stage, teachers develop their own multimedia materi-
als or Web sites for teaching. Data regarding application of and attitudes toward IT by NIE students were gleaned from the online survey of 491 NIE students, interviews with faculty and students, and evaluation of foundation course micro-lessons.

After taking the foundation and IT-integrated courses, all NIE students had acquired basic IT skills listed under the acquisition stage. Many students were able to apply their knowledge to classroom teaching, and some were able to create new multimedia materials or Web sites consistent with the innovation stage of IT competency. Among the students surveyed, 96.7% had computers at home, and 90.7% had Internet access at home. All reported a positive response to IT training. They agreed that they had improved IT skills as a result of courses at the NIE, and registered confidence in using IT in their classrooms.

A group interview with 15 students also revealed an increase in their familiarity with IT, confidence in their ability to plan and conduct IT-based lessons in school, and highlighted their strong interest and enthusiasm for IT. One student noted, “IT can recall the past, help us visit some places which, in reality, we cannot visit, and makes it possible to communicate with each other.” Another commented that, “I have gained a lot from this module, especially in the usage of IT for classroom lessons and also the use of PowerPoint to create slides to reinforce teaching.” Yet another, “I have benefited a lot from this module. Previously, my knowledge of IT was very limited. After this module, I can say I am quite proficient in IT although there is still much to learn.” Many students recommended greater access to lesson plans as they are developed by one another, which demonstrates the high level of interest in furthering their knowledge and application of IT in teaching. For example, one student suggested creating a Web site for free access to IT software for teachers. Another requested access to successful projects developed by previous students.

Three of the students interviewed were currently in their practicum. There, they found pedagogical strategies discussed in the IT courses to be of most help when integrating IT into their teaching. They reported being more active and confident users of PowerPoint materials and CD-ROMs than other teachers in their school settings, a point reinforced during interviews with the school principals.

For this study, four foundation course micro-lessons were evaluated by the researcher. The micro-lessons were intended to facilitate critical thinking and support student-centered learning. Consistent with evaluation criteria in the course, this observer examined technical, aesthetic, and pedagogical design aspects. The lessons had been assigned to reflect either cognitive or constructivist learning paradigms.

The first set of micro-lessons were to be created in information-based and multimedia book formats as tutorials with drills. They were based on cognitive and traditional instructional design principles. For example, they sought to utilize teaching elements such as small chunks, teach-practice-teach, and recall of previous knowledge. One of the lessons taught about musical instruments and another was designed for a technical course at the secondary level.

Both lessons integrated text, visuals and audio material with no technical errors, included attractive design components, and followed basic pedagogical principles of behavioral learning theory. More specifically, they identified behavioral objectives, presented small pieces of information step by step, allowed learners to practice, and assessed the achievement of the objectives at the end. However, neither lesson attempted to encourage students’ creative thinking, one of the learning goals of the NIE IT plan.

The second set of micro-lessons employed a constructivist learning paradigm. That is, the lessons sought to incorporate collaborative work rather than individual activities, integrated multimedia and hyperlink functions, and provided scenarios that promote higher-level learning outcomes. One lesson taught poetry writing and analysis at the secondary and college level. Specific guidelines in poetry writing were given, and students were asked to engage in poetry writing and analysis. The other lesson taught reflection and refraction of light at the secondary level. The lesson presented information, then engaged learners in a virtual experiment.

The poetry lesson used texts, visuals, audio and video to present the content. However, heavy use of multimedia revealed technical errors, such as a long delay when one moved among the screens. The physics lesson provided hyperlinks to relevant Web sites. Both lessons had aesthetic problems, in particular the visual design of the physics lesson was unattractive.
In terms of pedagogical design format, both lessons effectively used constructivist design formats such as contextualized problems, collaboration, simulation, and case-based learning. As in the first set of micro-lessons, questions inserted into the lessons did not appear to stimulate critical thinking.

In general, the first set of micro-lessons were more attractive and well-designed than the second, in which cognitive and constructivist learning principles were poorly integrated. Student understanding of resource- and problem-based learning seems to be weak. And attention to learning goals in the NIE plan regarding higher level thinking was inadequate. Nevertheless, the NIE students surveyed for this study have clearly made progress towards the use of IT in teaching, and their enthusiasm remains strong.

Observations of IT in Classroom Teaching

In order to evaluate the initial impact of NIE IT training on teaching practice in Singapore schools, four primary and one secondary level classrooms also were observed for this study. Of the five classes observed, three were taught by teachers trained by the NIE in IT.

The classes consisted of reading comprehension using a PowerPoint program; drawing a map with software downloaded from the Internet; researching the Internet to answer questions about endangered species; using software to draw a crab using step-by-step instructions; and using multimedia features to present stories and test thematic comprehension in an English class.

Strengths in these classes included use of IT as an instructional tool, and stimulation of critical thinking skills through use of leading questions. This was more apparent in the teaching of those trained in IT, who were more likely to act as facilitators than were teachers who had not recently completed NIE coursework. Each teacher also made some effort to integrate subjects across the curriculum, and students in all classes seemed to enjoy the IT-based learning environment.

Teacher attitudes supported IT training and integration within teaching. When interviewed, the NIE-trained teachers reported making effective use of the IT foundation course for specific lesson objectives. They found exposure to Internet-based materials and training in PowerPoint and Excel to be especially useful. Competing pressures on teaching time, such as preparation for Singapore’s national and district level examinations, was not perceived as an impediment to IT use in their work. They did, however, report that technical support from designated technicians was often delayed, and lessons involving Internet access required special arrangement for time in a separate computer lab.

The greatest problem observed was poor application of IT as a tool for individualizing lessons, especially relevant given Singapore’s tendency towards large class size. The average size of the classes observed was 40 students. NIE faculty, principals and school teachers interviewed did not generally perceive large classes as a problem; Singapore students often prevail in math and science over western students from smaller classes, and most schools would be unable to secure enough teachers for extra classrooms. In fact, a 1999 government plan to increase classroom space by 150%, to accommodate new IT facilities, made no mention of reducing the number of students per classroom. However, teachers reported finding it difficult to provide individualized feedback and instruction to each student in such large classes. Since IT offers tremendous potential for individualized instruction, this may need to become a higher priority in IT training at the NIE.
CONCLUSIONS AND RECOMMENDATIONS

Several conclusions can be drawn from this examination of the NIE IT plan and its initial implementation.

First, the NIE IT plan examined here represents a systems approach to the expanded use of IT. Key action strategies of the plan have included all the main functions of the preservice teacher training institute in four areas: curriculum revision, human resource infrastructure, physical and technological infrastructure, and research and development.

Second, NIE has been able to implement its IT plan with a strong commitment by all parties and abundant resources. This has enabled NIE to build a learning environment which integrates instructional technologies into administration, assessment, data manipulation, development and access to learning resources, multimedia-based communication, productivity, programming, publishing and research.

Third, the initial focus of NIE was to train its faculty to use IT effectively in the teaching process. The new training model for faculty tried to combine formal and informal training, and group and independent training to maximize the results of the training. Since training began, positive attitudes have been noted and faculty IT skills have improved. More time will be needed, however, to change teaching behaviors of the faculty and the culture of the Institute.

Fourth, curriculum revision has been undertaken to ensure that the preservice teachers are equipped with the appropriate skills to integrate IT into teaching and learning, and to allow the preservice teachers to experience the benefits of learning in an IT–integrated environment. This curriculum revision was undertaken in the broader context of Singapore’s creative and critical thinking initiative. The courses in general appear to have been effective in improving student knowledge and skills in the use of IT for teaching and learning.

Fifth, NIE will continue applied and strategic research and development in instructional science and technology. With the implementation of the NIE IT plan, several research projects have been conducted in each school within NIE. The School of Education and CITE have played a major role in these IT-related projects. However, IT-related research and development has been slow, and greater attention needs to be paid to long-term impact.

Sixth, NIE students who received IT training have shown a tendency to apply knowledge or skills they learned at NIE in their classroom teaching. Attitude changes among faculty and student teachers have been observed, but concrete conclusions with regard to the effects of NIE’s IT training on classroom teaching cannot be made at this time.

With these conclusions in mind, the following recommendations may help other countries and agencies seeking to integrate IT into teacher training programs and classroom teaching.

Integration of National Visions into IT Training for Teachers. As Singapore’s sole preservice teacher education provider, NIE has successfully integrated the national vision toward IT use in education into its IT plan. All the elements of the IT-integrated environment at NIE reflect IT-related goals in Singapore’s education system and in the Masterplan for IT in Education. IT training programs seeking to reflect national education policies should consider these points:

- Incorporate national visions in education into any IT training plans for preservice teachers;
- Include consideration of national policies for telecommunications and human development, given their impact on IT costs and the number of preservice teachers;
- Develop specific outcomes based on the national vision;
- Identify the appropriate means to achieve those outcomes; and
- Collaborate with national policy makers in the process of developing IT plans for preservice teacher training.

Adoption of a Systems Approach in the Change Process. In the NIE plan, instructional technologies are not seen merely as supplementary education tools but part of a whole new teaching and learning envi-
ronment. Reigeluth noted that “piecemeal change leaves the structure of a system unchanged. In contrast, systemic changes entail modifying the structure of a system, usually in response to new needs.” (Reigeluth, 1999, 16) Recommendations for adopting a systematic approach to the change process include:

- Identify all the functions or sub-systems of a preservice teacher training institute in the country/state/province. These functions may include hardware and software infrastructure, human resources development, support systems, research and development, and policy;
- Examine specific needs for structural changes in each area;
- Develop and implement strategies for meeting these needs; and
- Build a coordinating body to support the implementation process and promote its goals.

**Investment in Faculty Training.** Faculty members are unquestionably the key change agents behind adoption of IT for preservice teacher training. At the NIE, a variety of both formal and informal faculty training systems were provided so that faculty could take advantage of the methods which suit them best. Programs seeking to enlist faculty support and involvement should consider the following:

- Incorporate a variety of training methods such as face-to-face workshops and independent online training programs;
- Integrate informal supports into the formal training system so that less experienced faculty or staff can obtain timely assistance; and
- Provide multiple incentives such as workload reduction, recognition in faculty evaluations, and increased research allocations to encourage use of IT in teaching, and to compensate those providing technical assistance to others.

**Development of Outcome-Oriented, IT-Integrated Curricula.** Preservice teacher training courses must themselves model effective IT-integrated instructional practices. The NIE requires IT foundation courses and 6-12 hours of IT use in subject area courses. Students must produce IT-based micro-lessons applying pedagogical principles, which may be distributed to school teachers on CD-ROM. Training institutes might consider these points in incorporating IT into their curricula:

- Provide a short, hands-on IT foundation course at the initial stage of preservice teacher training; in order to reflect education goals, the course must apply IT to achieve wider pedagogical objectives;
- Provide more advanced IT courses as electives;
- Demonstrate IT-integrated teaching and learning by using IT in all academic subject matter areas; and
- Provide opportunities for students to produce and disseminate IT-based instructional materials.

**Partnerships between the Public and Private Sectors.** Various partnerships have supported implementation of the NIE IT plan; the MOE helped develop the plan, and private entities helped provide training to faculty and students at NIE. This experience suggests the following for constructive partnerships:

- Use packages provided by outside companies for cost-effective IT training; this collaboration allows the training institute instead to focus on the specific application of IT to pedagogical principles;
- Encourage students to design IT-integrated lessons within the practicum; this collaboration with local schools will expand awareness of the potential for IT use in the classroom; and
- Collaborate with the funding agency to secure required budgets and ensure that the training reflects national goals.

**Cost Effectiveness.** Most nations have limited resources for education and must make decisions based on cost-effectiveness. Even though most decisions at NIE have been based not on cost-effectiveness considerations but on quality improvement and human resources development for the country, NIE’s experience still provides several cost-saving strategies:

- Know basic hardware and software in order to negotiate best prices with vendors. Complimen-
tary peripheral devices can mean savings in hardware costs, just as free, public-domain software lowers costs. Some vendors include IT skills training with the purchase of computers;

- Maximize use of computer facilities to lower per student contact hour costs, as the NIE has done with efficient scheduling. Outside of school hours, computer labs could be opened to the public for a small fee;

- Reduce salary costs by contracting technicians on a part-time basis; and

- Form partnerships with other public and private sectors to share the costs of innovation. In training preservice teachers, NIE partnerships with schools, private companies, and other educational institutions in and outside of Singapore have accomplished this goal.
REFERENCES


**Table 1: Proposed IT Competencies for Singapore Faculty and Teachers**

**ACQUISITION LEVEL**

Objective: Demonstrates foundation computer skills and knowledge. Teachers should feel comfortable with the computer and be able to employ simple productivity tools to help them in administration, classroom preparation and personal work. At this foundation stage, it is most important for teachers to feel at ease working with computers even though they may not be too familiar with many of the technical details.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Specific Behaviors</th>
<th>Further Examples of the Competence</th>
</tr>
</thead>
</table>
| 1.1 Demonstrates a basic understanding of various terminology and concepts associated with computer systems, hardware and software | • Sufficiently comprehends the jargon used in computer advertisements  
• Understands new jargon that continually appears in newspapers, magazines and television programs  
• Understands the country’s copyright laws and other legal issues related to IT | • The teacher understands various basic computer terms such as megabyte, RAM, CD-ROM, CPU, etc.  
• Can define such terms as Internet, e-mail, IRC, video conferencing, etc., which appear regularly in mass media. New terms regularly emerge in the mass media, and the teacher should know how to find definitions of these terms  
• Since the legality of handling and duplicating digital materials from external sources is a growing concern, the teacher should be able to state general copyright guidelines related to IT  
• The teachers should appreciate some of the social and ethical issues connected with the Internet |
| 1.2 Executes basic functions of various popular operating systems (Windows, Macintosh OS) | • Demonstrates the ability to effectively use a computer operating system, including basic hardware (keyboard, mouse, etc.), and file saving, naming, copying, deleting  
• Demonstrates the ability to install CD-ROM titles and other software  
• Uses virus scan programs | • Teachers should be able to perform these file-management functions well without asking for assistance  
• It will be quite common for teachers to install various types of CD-ROM into their computers (personal, classroom, etc.)  
• Teachers should be able to follow instructions successfully to install various software programs and CD-ROM titles |
| 1.3 Uses a word processor | • Produces documents which show flexibility and discernment in font usage and style, paragraph format, tables, page layout  
• Is familiar with editing functions and able to use various tools such as spell checker, thesaurus, etc.  
• Incorporates graphics from clip art into documents | • Teachers should be able to type and format various layouts of worksheets and handouts for student use. Additionally, they should be able to use simple but effective designs, and to incorporate images obtained from the word processor itself or from commercial clip art CD-ROMs. Teachers should be aware of good design principles so that students can easily comprehend the intended message. |
| 1.4 Uses existing programs and templates to update students’ database, enter assessment marks, and generate student reports | • Understands the principles of spreadsheet and databases  
• Formats and sorts spreadsheet and database data to obtain various types of printed reports | • Teachers should feel comfortable enough to use spreadsheets and databases without fear of making mistakes  
• It is not necessary that most teachers demonstrate an advanced capacity for manipulating spreadsheets or databases. |

*Developed by Williams and Wong, 1999.*
Table 2: Proposed IT Competencies for Singapore Faculty and Teachers

**APPLICATION LEVEL**

Objective: Demonstrates effective pedagogical skills related to IT. The teacher needs to be able to integrate IT into lessons, to evaluate commercial instructional software, and to make informed decisions about the effective general use of IT to support lessons.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Specific Behaviors</th>
<th>Further Examples of the Competence</th>
</tr>
</thead>
</table>
| 2.1 Exhibits an understanding of educational principles behind effective computer-based learning (CBL) materials and their appropriate use | • Identifies the advantages and disadvantages of computer-based learning  
• Is aware of the pedagogical uses of computer-based learning materials  
• Is familiar with computer learning management systems  
• Is familiar with new paradigms of teaching in which the role of the teacher is as a “facilitator” of independent student activities | • Can identify the various instructional modes (tutorial, drill & practice, gaming, simulation, problem-solving) commonly found in computer-based learning materials  
• Understands some of the findings from research studies (e.g., meta-analysis reports) on the effectiveness of CBL  
• Explores various pedagogical issues related to the use of CBL (e.g., theories of motivation, learner control, cooperative learning, etc.)  
• Is able to identify learning situations where CBL could provide maximum help |
| 2.2 Selects and evaluates CBL software which are appropriate for the intended audience | • Uses an evaluation instrument to determine the quality of a given piece of CBL software, and can locate instructional materials from various sources | • Is able to critique specific CBL software applications |
| 2.3 Integrates CBL software and other relevant materials into the school curriculum, and designs classroom activities | • Plans lessons that will incorporate the use of computer resources (e.g., development of different computer activities for different students) | • Can plan lesson activities effectively integrating CBL software  
• The teacher is able to adapt lessons to fit particular sections of a CBL package  
• The teacher can design interesting CBL-based activities that will promote critical thinking |
| 2.4 Uses instructional applications and tools for the promotion of creative expression and communication | • Is familiar with the process of the development of creative expression and problem-solving  
• Designs lessons which guide students through the creative process, using IT-based instructional tools | • Teachers use software instructionally designed for students to express their ideas. Examples include students writing stories with a guided “writing assistant” (e.g., Creative Writer) or assemble mini “movies” of their own artwork (e.g., KidPix Studio) |
| 2.5 Understands the use of Internet as a teaching and learning tool | • Provides guidance for students to identify learning resources on the World Wide Web  
• Uses elements of Internet (e.g., chat, e-mail, discussion boards, newsgroups) for collaborative and cooperative learning  
• Designs relevant lesson activities for the Internet, used by the teacher, students or both | • Teachers integrate into their lesson plans direct access to the Internet. That is, the Internet serves as an integral tool during the lesson. The teacher may use the Internet during lessons for demonstration, for questioning students, and for other interactions with the students. Additionally, the teacher might construct lessons during which students are to directly access the Internet. There are also many possibilities for both teachers and students to use the communication capabilities of the Internet for intra-school and inter-school collaboration and discussion |
### INNOVATION LEVEL
Objective: Demonstrates innovative uses of IT in teaching and learning. Teachers at this level of competence can develop innovative lessons integrating IT in novel and flexible ways. Additionally, teachers are able to develop new multimedia micro-lessons for students, and are fluent in the design and use of instructional Web pages.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Specific Behaviors</th>
<th>Further Examples of the Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Uses various subject-based computer tools for learning</td>
<td>• Explores the use of subject specific software (for example, mathematics teachers at the upper secondary level should acquire skills in using software which allows the manipulation of mathematical functions, plotting trigonometrical functions, etc.)</td>
<td>• The use of subject-specific software allows teachers to extend the learning process (for example, students have a chance to observe simulations of scientific processes or mathematical functions. Or in art, students can use photo-editing software and paint programs to experiment with visual effects on a piece of art)</td>
</tr>
<tr>
<td>3.2 Plans for student use of general application tools (e.g., presentation, word processing, spreadsheet, database) for instructional purposes</td>
<td>• Understands the rationale behind the use of these applications as instructional tools • Designs classroom activities with these tools</td>
<td>• Teachers need to understand the theoretical aspects of constructivism in order to effectively use these tools • Additionally, they need to be able to facilitate the learning process in these kinds of learning activities</td>
</tr>
<tr>
<td>3.3 Creates interactive multimedia for instructional and professional purposes</td>
<td>• Demonstrates instructional design principles and procedures • Integrates pictures, photographs, video, sound and text into an interactive learning system • Constructs an interactive multimedia “micro-lesson” for use by students</td>
<td>• Teachers often find it necessary to create their own materials to supplement existing instructional resources (or perhaps because nothing exists at all). This skill is for teachers to be able to design and build their own “micro-lessons” (that is, small custom-made lesson episodes), using professional multimedia authoring tools and templates</td>
</tr>
<tr>
<td>3.4 Creates and maintains interactive and instructional Web pages and Web sites.</td>
<td>• Understands essential Web authoring concepts (e.g., HTML, Java scripting, intranet) • Demonstrates design principles and procedures relevant to instructional Web pages • Is fluent in using Web page design tools and HTML editors, as well as other supporting graphics and multimedia tools • Understands the structure of intranets and their role in the delivery of online instruction</td>
<td>• The instructional use of the Internet (or as it is called within a protected local organization, an “intranet”) will be an increasingly popular means for efficiently delivering instruction. Teachers with this competence are comfortable constructing effective instructional Web pages. Additionally, teachers are able to maintain whole instructional Web sites (intranets)</td>
</tr>
</tbody>
</table>
APPENDIX B

ASSESSMENT OF PERFORMANCE IN TEACHING FOR PGDE (PRIMARY AND SECONDARY)
Nanyang Technological University
National Institute of Education

Name of Trainee Teacher: _______________  Subject: ______________   CS 1/2/3*  Program/Intake: ______________
School/JC/Institute: _________________     Lesson: ______________   Lesson Observation: 1/2/3/4/5/6*

Class: _________________     Unit: ______________
Time: _________________     (*Please circle)

<table>
<thead>
<tr>
<th>PROCESSES</th>
<th>COMPETENCIES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PLANNING</td>
<td>• Delineating learning objectives ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Content knowledge ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Selecting content/materials/media ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Determining procedures ( )</td>
<td></td>
</tr>
<tr>
<td>2. DEVELOPING</td>
<td>• Arousing interest ( )</td>
<td></td>
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<tr>
<td>THE LESSON</td>
<td>• Stimulating critical/creative thinking ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Encouraging participation ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Maintaining pace of lesson ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Lesson closure ( )</td>
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<tr>
<td>3. COMMUNICATING</td>
<td>• Explaining and informing ( )</td>
<td></td>
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<td></td>
<td>• Questioning and responding ( )</td>
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<td></td>
<td>• Use of voice ( )</td>
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<td></td>
<td>• Command of language ( )</td>
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<td></td>
<td>• Using IT, media and other resources ( )</td>
<td></td>
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<tr>
<td>4. MANAGING</td>
<td>• Establishing rapport ( )</td>
<td></td>
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<td></td>
<td>• Managing behaviors ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Managing group/individual work ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Managing time ( )</td>
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<tr>
<td>5. EVALUATING</td>
<td>• Using and giving pupil feedback ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Monitoring pupil understanding ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Encouraging pupil evaluation ( )</td>
<td></td>
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<tr>
<td></td>
<td>• Using and marking written work ( )</td>
<td></td>
</tr>
</tbody>
</table>

Personal qualities exhibited for this lesson observation:
(circle YES or NO)

• Conducts self in ways befitting profession (e.g., dress code) YES/NO
• Sets a good example for pupils and colleagues (e.g., punctual for lesson) YES/NO

Comments on whether lesson objectives were achieved, what the strengths and weaknesses of the lesson were, and any suggestions for improvement:

Name of NIE Supervision Coordinator
### Basic IT Competency Checklist

**Word processing tool: (Yes or No)**
1. I can change text with different fonts and styles
2. I can copy text from one document to another
3. I know how to use headers and footers to insert page numbers
4. I know how to select and use bullets and numberings
5. I can insert and manipulate a table
6. I can draw figures
7. I know how to insert graphics or pictures into my document
8. I know how to insert a page break
9. I can change the Page Setup configurations
10. I know how to save my document in different format types, e.g., Word format or HTML format

**Presentation tool: (Yes or No)**
11. I can start a new file (using one of the templates provided)
12. I can edit the slide master to add or remove objects
13. I know how to use text tools--change color, size, font, style, etc.
14. I can resize and move objects, e.g., clip-art
15. I can add visual effects (e.g., slide transitions, build up or sequence of text)
16. I know how to change the order of objects (e.g., bring to front or send to back)
17. I know how to insert a graph or a table
18. I know how to create buttons, e.g., to create a hyperlink to another slide
19. I know how to save files (e.g., video, sound, graphics) to ensure that a slide show runs smoothly
20. I know of design elements that would make my presentation look good, e.g., font size above 20 points for readability, use of appropriate colors, etc.

**Electronic mailing tool: (Yes or No)**
21. I know how to read incoming mail
22. I know how to reply to incoming mail
23. I know how to send new mail to more than one person (through the address book)
24. I know how to change my password
25. I know how to delete mail
26. I know how to attach a file, e.g., a word document
27. I know how to read an attached file
28. I know how to save attached files to my local disk

**Internet navigation tool: (Yes or No)**
29. I know how to access a Web site given the (URL) address
30. I know how to search for Web sites through a search engine(s) given the key words
31. I can navigate from one Web page to another without feeling lost
32. I know how to “bookmark” any interesting sites that I may have discovered
33. I know how to “save” an entire Web page(s) as a local file on my disk
34. I know how to copy text and pictures from a Web page(s) to another document or file
35. I know how to upload my own materials onto my school’s Web site