Chapter 5

IT Training for Science Teachers Through a Subject-based Approach: Framework and Needs Analysis

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INTRODUCTION

After the return of Hong Kong (HK) from Britain to China in 1997, the new Special Administrative Region (SAR) government is becoming more proactive and forward-looking in many areas of public affairs. In particular, a long-term government policy on information technology (IT) in education was announced by Mr. C. H. Tung, the Chief Executive of HKSAR government in his first policy address (Tung, 1997) for enabling the HK economy and her labor force to catch up with other Asia-Pacific countries, such as Singapore and Taiwan, in the use of IT. In a word, it made a specific aim to empower school teachers to use IT to teach at least 25% of their curricula by the school year 2002/03. The major problem encountered so far is that most school teachers are lacking the sort of IT training, experience, and confidence necessary for using computers in classroom teaching and learning activities. Therefore, one of the most important components of the government's recent Five-Year Strategy (1998/99 to 2002/03) on IT (Education and Manpower Bureau, 1998) is *teacher enablement* which is closely geared with the other three main components, to wit, *access and connectivity*, *curriculum and resources support*, and *community-wide culture*. Those key components were derived from the four missions of their strategic plan as reproduced below:

- To provide adequate IT facilities for our students and teachers to enable them to access information;
- To encourage key players in the school system to take up the challenges of their respective new roles;

- To integrate IT into school education meaningfully through necessary curriculum and resource support; and

- To foster the emergence of a community-wide environment conducive to the culture change.

This strategic plan also concretely outlines how school teachers will be provided with IT training at four different levels – namely, "basic," "comfortable," "competent," and "creative" levels - in which about 25% of in-service school teachers and all new graduates of teacher education programs should reach the "competent" level by the school year 2002/03. According to the Teacher Survey 1999 conducted by the Statistics Section of the Education Department (2000), there were about 5,000 secondary teacher posts established in the subjects of Science, Integrated/General Science, Biology, Chemistry, and Physics. This implies that the IT training of 30 hours at the "competent" level, in addition to the 30 hours for the "comfortable" level, needs to be offered to more than 1,200 in-service Science teachers. For the training at the "basic" and "comfortable" levels, a general program for all teachers as provided by some computer/IT professionals or educators may be appropriate. However, when it comes to the competent level, it has been conjectured (see, e.g., Yeung & Ng, 1999) that a subject-based training approach would better cater for the needs of secondary teachers who normally specialize in teaching only two to three subjects. This is particularly true for Science teachers whose subject disciplines are so specialized in terms of content and pedagogy. Why do we advocate a subject-based approach for the IT training of Science teachers? Our rationales are based on and supported by the following features which are unique or peculiar to Science teachers and/or the teaching and learning of Science subjects.

Firstly, science educators and teachers have often been taking a leading role in the application of IT in education (see, e.g., DeHaven & Arieli, 1997; Escalada, Grabhorn, & Zollman, 1996; Jones & Berger, 1995; MacIsaac, 2000; Marx, 1988; Rodrigues et al., 1999). The obvious evidence is that there are already plenty of Science-related multimedia resources (see, e.g., Yeung, Lai, & Lee, 1998) available in CD-ROM and/or World Wide Web (WWW). Many possess various unique features (see, e.g., McCormack & Jones, 1997) and special requirements (e.g., plugins and hardware for 3D or virtual reality) will necessitate special training for their effective use (Colazzo & Molinari, 1996; Marshall, 1995) in schools.

Secondly, there is a growing trend of using datalogging systems (see, e.g., Frost, 1997; Ng, 1997; Ng & Yeung, 2000) together with various sensors in many science experiments to facilitate measurement, data collection, data analysis, and graphic presentation of results. In UK, the National Curriculum on primary science education requires students to discuss sensors in systems at Key Stage 1, for example the smoke alarms. At Key Stage 2, students will be taught how to use IT equipment and software to monitor external event. In other words, pupils need to be taught to use sensors to keep track of things. The development and applications of those and other types of computer-controlled experiments are quite unique in the Science disciplines and so it will require both Science subject knowledge and Science-related IT hardware and software experience as well as the principles of instructional design for effective implementation (see, e.g., Andrews et al., 1995; Brooks, 1997; Friedler et al., 1990; Marshall, 1995; McCormack & Jones, 1997; Ng, Kwok, Yeung, & Yeung, 1997).

Thirdly, computer-simulated experiments (see, e.g., Pilkington & Parker-Jones, 1996; Watkins, Augousti, & Calverley, 1997) are much more common in Science (rather than other disciplines such as languages) for demonstration and laboratory practices. They will in particular become more widely used in place of those laboratory experiments that are either too fast, too time-consuming and too costly, or potentially hazardous (see, e.g., Rios & Madhavan, 2000). Again, intensive subject-specific knowledge and experience are required to source, select, evaluate, adopt and/or develop the suitable software for effective teaching and learning in schools.

Finally, in general, Science teachers are holding a relatively positive attitude (see, e.g., Berger, Lu, Belzer, & Voss, 1994; Blake, Holcombe, & Foster, 1998; McKinnon, Nolan, & Sinclair, 2000; Mitra & Steffensmeier, 2000; Shaw & Marlow, 1999; Yeung, Cheng, So, & Tsang, 1998) towards new technology like IT, and they are faster in mastering the technological skills because of their science background. A recent survey conducted by Ng, Kwok, and Yeung (1998) revealed that 96% of Science teachers in Hong Kong are having their own personal computers and two-thirds of them have Internet access at home. Therefore, their background knowledge, preferred mode of learning, and focus of interest in the IT training course should be substantially different from those of other subject teachers, leading to the demand for a subject-based training course specifically designed for them.

Therefore, there are strong arguments and rationales for adopting a subject-based approach in developing courses on how to make effective use of IT for Science teaching, and the design of those IT training courses should be geared to the needs of in-service Science teachers. In fact, the spirit underlying the advocacy for a subject-based approach is in line with Lee Shulman's (1986) introduction of the Pedagogical Content Knowledge (PCK) which stresses on the "representation of ideas, use of analogies, illustrations, examples, explanations and demonstrations... as ways of representing and formulating the subject that make it comprehensive to others" (Shulman, 1986, p. 9). While examplary applications of PCK and constructivisim in science education can be found in many recent research reports (see, e.g., Fensham, Gunstone, & White, 1994; Gess-Newsome & Lederman, 1999), a subject-based approach in IT training for science teachers has not been a focus of research in this context. The main reason is that IT deals with, at the technical level, the hardware, software, or courseware for presenting scientific concepts and models by means of computer-related equipment or electronic media. It should be classified as a kind of curricular knowledge like teaching aids or educational technologies in Shulman's (1986, p. 9) definition of the three categories of content knowledge, and so it is different from the original notion of PCK which emphasizes on instructional strategies for the representation (rather than merely technical "presentation") of ideas in specific subject topics.

On the other hand, the ignorance of the subject-based approach in most government official IT policy documents is largely due to the fact that, firstly, the groups of people who draft or give advice on the government's IT implementation plan consists mostly of the IT professional or educators and, secondly, there are currently rather few subject experts with strong IT training or experience, especially in the non-science disciplines. The drawback or potential loss of the insiders' full control or planning on the IT approach can best be illustrated in the following two cases:-

- Tim Berners-Lee who was an Oxford Physics graduate and invented the WWW at the European Laboratory for Particle Physics of the European Organisation for Nuclear Research (CERN) in Geneva recalled that his first paper on the WWW was rejected by the IT community because of violating "the architectural principles that hypertext systems had worked on up till then" (Berners-Lee & Fischetti, 1999, p.50). Due to the support of the CERN laboratory (Cailliau, 1998) which is managed by Physicists rather than IT professionals, Berners-Lee's WWW idea could fortunately be implemented and turned out to be one of the most important invention in the 20th century. The ignorance of the IT professionals is probably due to their belief in what are known within their community.

- In Hong Kong schools, the Windows NT (Chinese and/or English versions) was cloned by the Education Department as the default operating system in most personal computers because of its better stability and security control as recommended by the IT professionals. This choice of a more expensive operating system has led to a very severe problem that prevents subject teachers from using computers in classroom teaching and learning activities, because the educational software or CD-ROM courseware in many subjects are designed mainly for the Windows 95/98 systems only (rather than for Windows NT) and the Windows NT is too difficult for most teachers to use effectively. Some schools have recently given up the Windows NT platform and replaced it by the cheaper Windows 98 systems in their computers despite of losing the license fee already paid. If the advice from the subject teachers had been sought, such a case of wasting resources would not occur.

Similar kinds of protectionism, vision confined and bounded within a professional community and conflict of interest (e.g., the Y2k computer bug issue), are very common in many professional bodies, and the best way to overcome this is to seek advice or opinions directly from the users. Fortunately, the situation is now changing very rapidly and there are a few subject-based workshops appearing in some local IT in education conferences. We believe that this is the right educational trend that we should promote and follow closely. A concrete subject-based approach model will be described in the next section.

THE SUBJECT-BASED APPROACH MODEL

Brief Outline

Based on the arguments mentioned in the previous section and our past teaching and research experiences on IT usage and courseware development in the Hong Kong educational environment (see, e.g., Ng et al., 1997; Ng et al., 1998; Yeung et al., 1998) as well as the IT approaches and policies found in the following countries:

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