Collaborations of Three Educational Parties in Leading IT Development in Mathematics Education

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Abstract

Most IT researches in mathematics education are confined to classroom settings [5], ignoring the surrounding conditions for their practicality. In this paper, an innovative collaboration of three educational parties: teaching frontiers, curriculum developers and academic theorists, e.g.[1], are all involved.

The 3 authors endeavor to: (i) address pedagogical, teacher-training, policy-making problems *when the parties are functioning separately without mutual adaptation* at present and share value-dilemmas encountered by the three educational parties in Hong Kong; (ii) adopt and examine an integrated school (hybridizing ‘top-down’ and ‘down-up’) approach in perpetuating *regionalised IT school culture* in order to consolidate forthcoming school-based mathematics curricula in Hong Kong and even other Asian countries in the next century; (iii) discuss some activities on using various components of IT in teaching and learning mathematics in day-time lessons and after-school activities by the new approach.

1 Introduction

Since the Education and Manpower Bureau (EMB)'s publication of 'Five-year Strategy' in 1998 [7], IT education has been foreseen to be a feasible path for enhancing teaching and learning in Hong Kong. After the publication of the new mathematics (2001) secondary syllabus in 1999[6], IT as a new teaching and learning tool has become a great challenge to the educational system of Hong Kong. Appropriate uses of IT stressed in the syllabus have become attainable educational goals for many school teachers, principals and educators.

In Hong Kong, the 'top-down' approach initiated from curriculum developers / policy-makers to school level has been adopted for many years [14]. It is difficult for them to measure the degree of implementation of the intended school curricula at classroom / school level. Sometimes universities or in-service teachers' associations have joined to help consolidate the implemented curricula when launching teacher-training programs, hands-on workshops and providing teaching and learning resources. Yet after 2-year informal discussion with school colleagues, some problems are emerged in 'deepening' IT mathematics education at class /school level:

(i) no continual professional nourishment in IT education for in-service teachers from universities ;
(ii) lack of school-based IT resource support ;
(iii) unfavorable school-based IT culture ;
(iv) in-service teachers' limited access to desirable IT training courses offered by Education Dept.(ED) or universities ;
(v) Worst of all, no favorable environment for enthusiastic teaching frontiers to share their 'ups and downs' when using IT in their day-time lessons.

Without gaining continuous (physical, financial, psychological and spiritual) supports, school-based curricula, stressed in the new mathematics syllabus, may not be easily implemented and devoted IT school reformers' ardor may 'fade away' eventually before the actual implementation of IT.

2 Lack of collaboration of 3 educational parties

One tragic instance was the sudden dismissal of $\mathbf{T^{-3}}$ (**T**eachers **T**eaching with **T**echnology) workshops organized by Hong Kong Association for Science and Mathematics Education Ltd. (SME) under the support of Texas Instruments Co. Ltd.. From July 1998 to Nov. 1998, such T^{-3} monthly workshops were established to enhance secondary school teachers' professionalism in mathematics education through graphing calculators, internet and PC software in Hong Kong, reported in [2]. The underlying reasons for the closing down of the workshops were revealed by the main author in a recent semi-structured questionnaire survey:

(i) core members were heavy-loaded without much 'free time and space' for initiating IT day-time lessons, being foreseen in [9];

(ii) they lacked sufficient support of IT teaching strategy or worksheets (in Chinese and English) from universities / professional teachers' associations;
(iii) they gained no consensus with school colleagues in using IT.

On evaluation, this instance revealed that curricula developers have not thoroughly collaborated with school teachers and educational researchers. Not much adjustments in lightening teachers' workloads or no co-ordination of IT resources have been made at policy-making level since the Five-year Strategy [7].

2.1 A Conceptual Model for understanding the current situation about IT educational development

Based on Fullan & Stiegelbauer [8]'s **3-R** model, the initiation of IT educational reform has not been *well-prepared* since the school year 1998/1999:

1. **R**elevance:
   (a) im*practicality of educational aims:* in the Five-year Strategy(1998) [7], quantitative allocation of IT components in school curricula (e.g. how many percentages of students / teachers being competent in using IT) may not necessarily guarantee quality education in teacher training and students' learning through IT ;
   (b) *dissatisfaction of teachers' needs***:** they cannot realize the potential of IT education under the tight working schedule of about 25-33 school lessons per week.
2. **R**eadiness:
   (a) teachers' *incapacity to use IT:* some are reluctant to use IT in day-time teaching, leading to under-use of classroom PCs, besides administrative problems, reported in [3] ;
   (b) *variation in teachers' IT learning***:** standardized IT training courses should have accommodated their cognitive learning differences, reported in [12] .
3. **R**esources:
   unavailability of IT resources: in most secondary schools, 82 extra PCs promised in the Five-year Strategy (1998) [7] have not been properly installed till the school year 1999-2000, leading to limited exposure to IT environment.

2.2 Complexity of Problems in using IT in Mathematics Education

Based on in-depth interviews with some staff in various sections of Education Dept.(ED) by the main author, there are value dilemmas in promoting IT in secondary schools:

a. *centralization vs. decentralization in allocation of school resources*: The original resource allocation mechanism , adopted by ED has been centralized for many years. Time is required to decentralize it so that schools can flexibly fulfil their needs in getting IT resource e.g. extra PCs from vendors.

b. *limited manpower and financial resource*: Under limited human and financial constraints, it is infeasible to expand teaching staff drastically to lighten daily working schedule. Teacher-centered training courses at different levels require a great number of experienced IT trainers which are under supply in the initial stage.

c. *In-service teachers' psychological barriers to learn and use IT*: Such natural phenomena in launching technological reforms cannot be easily tackled by ED or universities.

In view of vigorous technological growth every year, there are many uncertainties ahead in IT education. In fact, what we needs is a continuous exploration of many *know-hows* on *how to use, manage and operate* IT in order to enhance teaching and learning. *The three educational parties need to understand the multi-facets of educational problems individually caused by each party, share value dilemmas and try to optimize feasible solutions in short / long terms under manpower, financial and resources constraints in some try-out* projects and plans, which are known as 'action research / plan'.

3 A Broad Conception of Action Research / Plan

Action research / plan, in narrow sense, is a kind of reflexive teaching undertaken by school teachers (as action researchers) across and within school years [10]. In its broader sense, teachers, curriculum policy-makers and academic researchers can work together with their own distinctive goals / values [table 1] in ceaseless cycles of observation, implementation, evaluation and adjustment [fig. 1]. This research suffices to foresee or bypass any unexpected disparities among intended, implemented and attained curricula, induced by IT.

Table 1: Distinctive roles of three educational parties' collaboration in action research

Role of Agents in action researches / Pans	**Underlying Goals / Values**
Curriculum designers / developers (*at intended curriculum level*)	to find out appropriate directions of IT in educational policies
curriculum policy-makers / academic researchers (*at implemented curriculum level*)	to gain conceptual understanding / articulate theories accounting for students' construction of knowledge fruitfully through IT

Teachers (*at attained curriculum level*)	to discover those favorable conditions for enhancing teaching and learning through IT

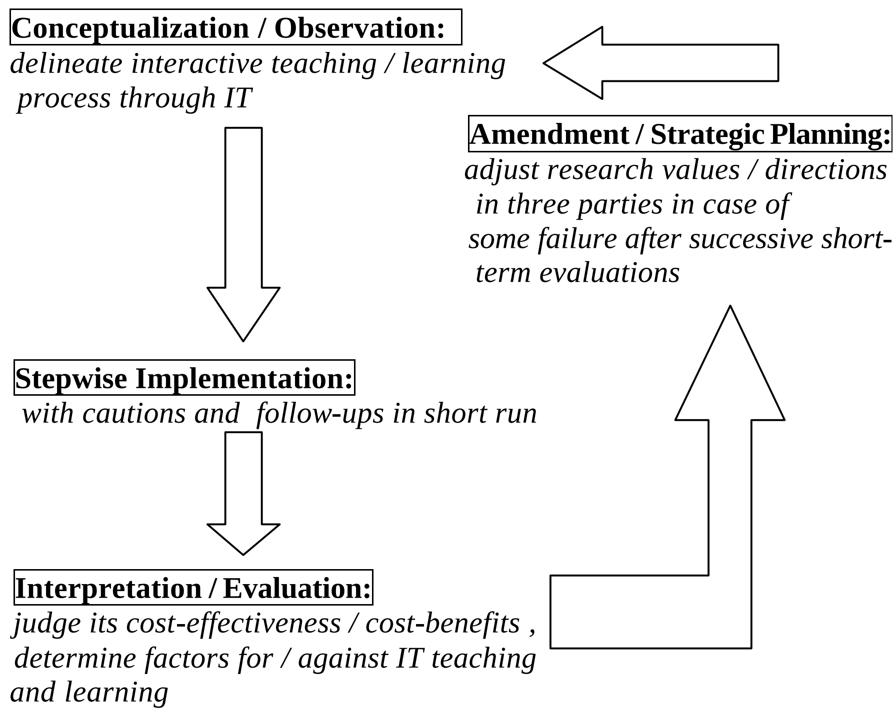

Figure 1: ceaseless cycles through collaboration of educational parties in action research (modified from [13] , p. 67)

4 A Historical Development of IT during the Review / Revision of Secondary Mathematics Syllabus

Being an advisory body for curriculum development in Education Dept. (ED), the Curriculum Development Council (CDC) Mathematics Subject Committee (at secondary level), whose members including the second affiliated author, has started to review the current secondary mathematics curricula from 1995 to now. Pedagogical roles and potential benefits of IT in mathematics education became a controversial issue during the revision process. Such period can be roughly classified into three stages in adopting IT in mathematics education, namely:

1. stage 1 -----*reservation* (1995-1996) ;
2. stage 2 -----*awareness* (1996-1997) ;

3. stage 3 ----- *adoption* (1997-1999) .

In the first reservation stage, IT was not regarded as beneficial to students' learning. Teachers and some educators, including some members of the Subject Committee, were not familiar with the pedagogical uses of graphing calculators and applications of PC software in teaching and learning mathematics. Some subject committee members worried about the side-effects of IT like its undermining students' written (in paper–pencil mode) and mental computational skills and even their fluency in mathematical abilities. Yet no empirical research was involved to prove / disapprove anything about IT. Under such circumstances, computer software package served as an enrichment (an optional topic) component in the draft outline in 1996.

Started from the second stage, small-scale class-based IT training programs were provided to in-service teachers by some universities in early 1997 commissioned by ED. Whilst being increasingly familiar with various PC software, members of the Subject Committee worried about non-readiness of in-service teachers in using IT. After the provision of 15 PCs to primary schools by the promises of the Chief Secretary in 1997/98, the Subject Committee was fully aware of the impacts of IT in mathematics education. Heated discussion included on whether algebraic / numerical representations undermine students' cognitive understanding in graphs. Try-out schemes from secondary one to secondary four involving the uses of graphing calculators and software packages were initiated yearly in totally 26 classes of all types from 1997 to 1999 to testify the fruitfulness of IT education with evaluations.

Since the publication of Five-year Strategy (1998) in the third stage, the Subject Committee has become more open to the use of IT in mathematics education. Taylor's model [15] was adopted and modified by rendering IT as a tool, tutor and tutee in the new S.1-S.5 mathematics syllabus in 1998. To strive the balance of teaching mathematics using IT as an end and as a means, the Subject Committee suggested "the appropriate use of IT in mathematics". Flexible selections of IT components including resourceful internet web-sites were suggested with the aid of software exemplars under constant revision.

4.1 One Inspiring instance of action research

Since 1997, one try-out scheme [initiated by Curriculum Development Institute (CDI), the CDC's guiding secretariat] has undoubtedly played a vital role in testifying the roles/ directions of IT in mathematics education in classrooms *with the co-operation of school teachers.*

New pedagogical problems foreseen by the try-out scheme IT are as follows.

1. *teachers' / students' strategic incompetence* : Most teachers only started to learn operational knowledge without sufficient time to master strategic

knowledge in using IT software in teaching whilst students had inadequate operational knowledge in using graphing calculators, consisted of many functional keys and their varied cognitive abilities in learning how to use IT caused the deferment of original lesson plans.

2. *unavailability of IT resources* : it was time-consuming to set up IT and its peripherals before teaching and learning since IT facilities were not properly installed; there was lack of quality software in the private commercial market; intractable lighting, spacing problems emerged in classrooms.
3. *unfavorable conditions for construction of mathematical knowledge*: some students were distracted by IT (as a mean), instead of learning mathematical concepts (as an end).

5 Integrated School approach in Regionalising IT Culture

By the collaboration of three educational parties, an innovative action research paradigm has been proceeding since the writing time of this paper.

By focusing on one region called Tuen Mun for minimizing human and physical resources, an IT resource center, with daily network support of IT coordinators and technicians, has been established for two purposes: firstly, provision of sufficient IT resources and frequent IT training seminars / workshops to needy teachers working in the region; secondly, setting up good regional atmosphere for enhancing their professionalism in using IT. This is known as 'integrated school approach' in regionalisation of IT culture' in fig. 2. In order to reduce destructive competition among some schools in the region, cross-regional support can come from other enthusiastic teachers. On reflection, there are numerous advantages in adopting such new integrated approach [without necessarily resolving all the value dilemmas / problems mentioned in the above section (2)]:

1. Allocating IT resources with flexibility and effectiveness in launching school-based reforms within the region;
2. Reducing the gap between IT taught in schools and the growing technology in IT industries in [9] by inviting representatives of the IT industries to inform students of the current trend of technology, related to their daily life.
3. Formulating feasible school-based IT worksheets and lesson-plans to enrich the resources in the regional resource center;
4. Shaping up a high-profile IT regional culture, in which sharing of values and beliefs in IT, awarding rituals / ceremonies in promoting IT, clear-cut school vision and mission in IT and learning lessons from some heroes / heroines (expert teachers in IT education) are all involved.

   It is expected that such ongoing IT development in Tuen Mun can further 'activate' school colleagues in other regions by cohort effects. This intra- / inter-regional development can eventually speed up the overall IT educational development in Hong Kong.

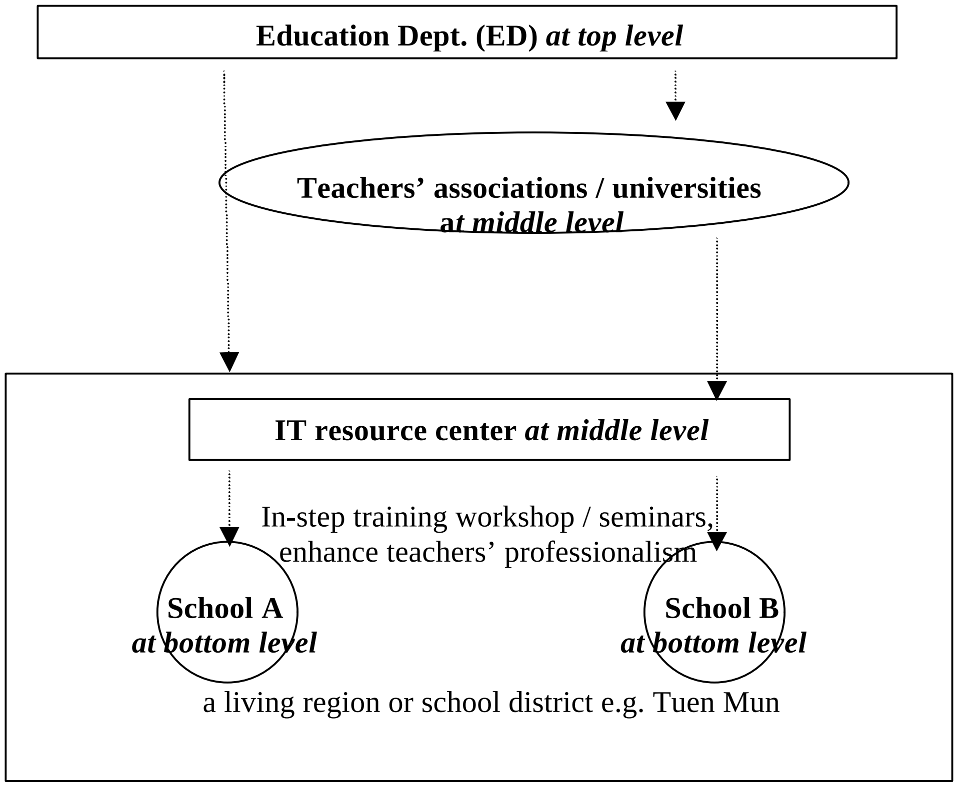

Figure 2 : Integrated school approach for regionalisation of IT education

5.1 Sharing valuable teaching and learning experiences at classroom level

There have been basically two types of IT activities, co-organized by the three educational parties so far:
Activity 1: one school-based dynamic geometry competition (in June 1997 and from Feb. to May 1998) for secondary students in one government secondary school, apart from another inter-school IT competition reported in [4];
Activity 2: school-based IT lessons / students' problem-solving activities in one government secondary school [in which most students have a good mastery of leadership and presentation skills] and one regionalised activity for secondary students of four schools in Tuen Mun (from Feb. to July 1999).

Their evaluations are:
1. School teachers can improve the contextual conditions for IT education progressively through action research;

2. Open-based investigations with new learning perspectives motivate students' learning under teachers' suitable guidance;
3. Students can have a good mastery of problem-solving / investigation skills, not being covered in traditional pedagogy;
4. Students' leadership, group discussion and presentation skills can be greatly enhanced, besides those rigid examination-oriented learning objectives [11].

Precautions should be made on the *gaps* between virtual reality in IT media and actual mathematical reality [12]. Different sorts of IT in various contexts may have limitations in their virtual reality representations, which were learnt from unsuccessful past experiences:

(a) For graphing calculators like TI-92 , students need to set up appropriate x- and y- scales before using them to draw graphs. This is a form of IT operational and strategic knowledge;
(b) Students should develop cognitive understanding of the differences between numerical approximations and actual values represented. For example, in using Cabri II / Sketchpad, measuring values like angles with approximations may cause undesirable discrepancy when visualizing the theorems in geometry of circles.

Without paying suitable attention to such limitations of various components of IT in mathematics education, predetermined goals and objectives at various levels cannot be achieved easily

5.2 A Lesson learnt from Hong Kong

At present, most curriculum developers, educational researchers /educators and teachers often focus on how IT is integrated into curricular systems, research settings and classrooms *separately*. Such 'alienation' approach face co-ordination problems, listed in the above sections (1) and (2).

In this paper, the authors aim to suggest an integrated school approach, mediating among the three parties' positions. No doubt, such collaboration of three parties may cause additional short-term co-ordination problems. However, in the long run, such approach can make positive progress in transforming school / regional atmosphere through IT in mathematics education by broadening the viewpoints and strengthening the functioning of the three parties.

We deeply hope that the above discussion can help the three educational parties in other Asian countries formulate feasible IT researches, policies and develop well-balanced mathematics curricula for educating younger generations in the 21st century

END

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