http://www.ifip.org/

AERA 2007 Symposium

Global Perspectives on Technology as a Change Agent in Teaching and Learning Identified by Educational Researchers in the International Federation of Information Processing

Unit: SIG-Technology as an Agent of Change in Teaching and Learning

Time: Thu, Apr 12 - 12:25pm - 1:55pm

Building/Room: Marriott / Chicago Ballroom, Section H - Fifth Floor.

Page	Contents

Symposium Overview

Chair & Introduction: Niki Davis &Andrea Kárpáti, Past Chair and Vice Chair of the International Federation of Information processing (IFIP) Working Group 3.3 for Research

Papers:
Margaret Cox, Kings College, University of London, UK
Niki Davis, Iowa State University, US
Jianwei Zhang, OISE/University of Toronto, Canada
Andrea Kárpáti, Eötvös Loránd University, Hungary

Respondent:
Lynne Schrum, AERA TACTL and George Mason University, US.

Abstract
This symposium is proposed the International Federation for Information Processing (IFIP) working group for educational research (WG 3.3) with the goal of stimulating collaboration between this IFIP and the AERA SIG Technology as an Agent of Change in Teaching and Learning (TACTL). The AERA 2007 conference theme "The World of Educational Quality" is a timely call to address our complementary missions to improve research while also working across boundaries of nations, disciplines and cultures. This symposium will present a set of papers that draws upon research informed by IFIP's activities. The proposed perspectives on research of technology in education are: historical, multidisciplinary studies of technology diffusion, teachers' professional development, plus additional perspectives from Asia and central Europe.

Objectives of the symposium

This symposium is proposed by researchers in the International Federation for Information Processing (IFIP) working group for educational research (WG 3.3) and its members, many of whom are also members of the AERA SIG Technology as an Agent of Change in Teaching and Learning. The AERA 2007 conference theme described by AERA President Eva Baker (2006), "The World of Educational Quality", is a timely call to us all to support each other's mission to improve research while also working across boundaries of nations, disciplines and cultures. We see the conference theme as an invitation to our international working group to explore the complementary missions of AERA's TACTL SIG and our IFIP WG 3.3 missions. This symposium will present a set of papers that draws upon research informed by IFIP collaborations, including workshops. We hope it will result in a plan for collaboration between AERA TACTL SIG and IFIP WG 3.3 as well as increasing participants' global perspectives.

IFIP was established with a mission to provide impartial views on technology and support work of international agencies, including the U.N. agency UNESCO. UNESCO supports change through policy makers, educators, and researchers. Within IFIP, the educational mission is led by its Technical Committee 3, for education, and TC3's working groups including working group 3.3 for research. During the past year IFIP's

technical committee for education has refreshed its mission and seeks to reach out to increase the use and quality of educational research.

Each year IFIP working groups hold conferences and workshops to develop knowledge and improve research and often resulting in edited books that bring together important global perspectives on the conference theme. In addition, the World Conference on Computers in Education is held every four years and results in a global sharing of research and practice, most recently in South Africa in July 2005. Strategic work is an integral part of IFIP works, e.g. The Stellanbsoch Declaration (IFIP, 2005) to improve equitable access to technology resulted from that WCCE05 in South Africa, as well. Members have also contributed to important UNESCO sponsored events such as the UNESCO global conference on building capacity for ICTs (Information and Communication Technologies) in Paris in May 2005, which included satellite meetings in most regions of the world (UNESCO, 2005; Davis 2005).

Educational and Scientific Importance

The beginning of the twenty-first century has brought some maturity to research on technology as an agent of change in teaching and learning. Naive techno-rational views promoted by vendors and techno-evangelists are being replaced by research informed views of the quality and applicability of research in this area. At the same time techno-economic forces are affecting access to information and resources in all parts of the world (Dutton, 2004) and pushing increased demands for education, including in third world nations as part of the United Nations' Millennium Development Goals (2005). There is a need to promote these global perspectives in research and leadership of change in education. This promotion of global perspectives across nations, disciplines, and time is the purpose of this symposium.

The Symposium Presentations

The theme of the posed symposium is change toward more global perspectives on research and practice on technology as an agent of change in teaching and learning.

The symposium will be introduced by Andrea Kárpáti, vice chair of the International Federation of Information Processing (IFIP) Working Group 3.3 for research on ICT in education (WG 3.3). She will highlight key contributions by IFIP Technical Committee 3 on Information and Communication Technologies (ICT) and Pedagogy, including its recently established Life Long Learning (LLL) interdisciplinary group of about forty researchers representing seventeen countries from four continents who have formed a knowledge building community to compare and contrast research and development related to LLL. Dr. Kárpáti, UNESCO professor of ICT in education, will summarize WG 3.3 research initiatives, major position papers and international declarations prepared over the last five years and introduce the panel. The introduction will also present future aspirations including its planned book, special journal issue. The introduction will conclude with introductions to the four papers that have global perspectives informed through the authors' IFIP membership.

Margaret Cox, Kings' College, University of London, UK

The Changing nature of researching IT in education

Research into the uptake, use and impact of ICT in education has been conducted from a growing number of perspectives. The earliest approaches to research into ICT in education initially focused on the effects of a particular computer program on students' learning. This was because the main purpose in the 1960s and 70s for using ICT in education was to enhance existing teaching and learning practices or to present the existing curriculum in innovative ways. The research and development of ICT in educational settings was therefore intertwined with the design of the ICT tools themselves and as well as focussing on the impact which these had on students' learning. It also provided feedback for improving the software design.

During the development of ICT in education in the last forty years there has also been an extensive growth in educational research generally and in our understanding of the impact of the wider educational experiences on students' learning alongside revolutionary changes in the ICT industry itself. Researching the effects of ICT on students' learning now includes measuring the consequences of collaborative learning; the increasing autonomy of the learner; the relationship between the immediate learning experience and the wider learning context; the role of the teacher and many other influences. This paper will review and analyze the methods and techniques which have been used over the last forty years to research the impact of ICT in education drawing on evidence from many previous research studies and their effectiveness as research tools to measure the impact of ICT in education.

Cultural Adaptation of Technology and Learning Innovations in Asia: An Emergent View

Jianwei Zhang, OISE/University of Toronto, Canada

Much early research of educational technology searched for "media effects" – whether a medium is better than another in causing effective learning. An unfortunate conclusion was that comparing the effects of different media is not a productive question for research, because media effects can never be separated from method effects – effects of instructional designs (e.g. Kozma, 1994). A critical look at current research of technology and classroom change unveils that researchers ask a similar question as media effects, but focusing on technology's effects on teachers and schools, with questions such as: Can new technology cause innovative pedagogical practice or classroom culture? Learning technology research has relied too much on an analytic approach focusing on resultant and mechanical effects, as opposed to emergent and "chemical" ones (Sawyer, 2003).

Drawing upon an emergent view of pedagogical culture as a complex system, this paper analyzes technology-culture interaction in East Asia in comparison to the Western world. In the Eastern pedagogical culture, which is more top-down, group-based, teacher-directed, and knowledge-focused, Asian teachers tend to select and use content-bounded teaching tools to aid expository but reflective group-based teaching, either in face-to-face

or in distance learning environments. To promote profound change of a pedagogical culture, technology innovations need to be woven into systemic efforts of reform. The analysis of the new curriculum reform in China will be elaborated a case of how teachers experience and respond to complex conflicts and discrepancies during systemic change.

Global interdisciplinary research into the diffusion of technology innovations in education

Niki Davis, Iowa State University

Interdisciplinary research into the diffusion of innovations has been led by Everett Rogers (2003) over the past four decades, starting with the seminal study of agricultural innovation in Iowa during his doctoral studies at Iowa State University. Little of that research has touched TACITL, so Niki Davis spent her recent study leave studying Rogers' work and gathering research and theory relevant to TACTILE with support form IFIP colleagues. A review of that research will be presented using four perspectives, often called units of analysis. The perspectives on the diffusion of information technology innovations in education start with that closes to us all, the individual. They then move to encompass the organization and the change agent before adopting a global systems perspective. Each perspective will be illustrated with both theoretical models and research studies, including those by the author over several decades.

These multiple perspectives also have the potential to increase the quality of research by clarifying variables, feedback loops, cycles and units of analyses. This framework will also be outlined briefly.

Research on ICT Competencies of the Life Long Learner – an International Perspective

Andrea Kárpáti, Eötvös Loránd University

In the recent years we have experienced a paradigm change in education as our societies have transformed into Knowledge Society that has extended the notion of lifelong learning to include everyone. Nowadays *we all need to be life long learners* – researchers of meaning and form of continuous improvement and innovation both in our public and private lives. The paper presents one thematic area of the work of the IFIP LLL Focus Group (introduced earlier). Competencies are researched as broad categories overarching ICT skills and any other learning skills relevant for all phases of life. Major research studies of ICT competency (SITES, IEA, OECD – ICT and the Quality of Learning and DESECO, UNESCO – Promoting Equity Through ICT) will be summarised. The significance for the Life Long Learner of major areas of competence related to ICT, present in all evaluation studies will be discussed:

- Interpersonal and communication skills (Usage of ICT tools interactively)
- Computer technology competencies
- Visualisation skills
- Information retrieval, filtering and presentation skills
- Algorithmic thinking skills
- Digital creativity: autonomous (self) expression with digital media

Structure of the symposium

Papers for all speakers will be used to stimulate an early online conversation across both TATILE and IFIP WG 3.3 using technology. Messages from that prior online discussion will be brought into AERA symposium using a laptop computer and projector, and a small selection incorporated by the session chair and participants.

Within the proposed AERA 2007 conference the symposium will be introduced by Niki Davis Andrea Kárpáti who will provide an overview of IFIP WG 3.3 and its mode of working, public outcomes, and future aspirations (described earlier). She will also provide coherent introductions to the speakers.

Each speaker will make a short presentation, including at least one key study with research evidence, followed by an opportunity to discuss this perspective.

Following IPIP presenters there will be a response to the symposium and its papers from the TACTL SIG's leadership by the past SIG chair Lynne Schrum, George Mason University. This will be followed by a plenary discussion and concluded with short concluding remarks by IFIP and TACTL leaders.

Order of Presented Papers:

1. Margaret Cox, Kings College, University of London, UK
2. Niki Davis, Iowa State University, US
3. Jianwei Zhang, OISE/University of Toronto, Canada & Beijing Normal University, China
4. Andrea Kárpáti, UNESCO Chair at Eötvös Loránd University, Hungary

Paper 1

The Changing nature of researching IT in education

Margaret Cox, Kings' College London, University of London, UK

Abstract

Research into the uptake, use and impact of IT in education has been conducted from a growing number of perspectives, with many assumptions and limitations regarding research approaches used and analysis of findings. The earliest approaches to research into IT in education initially focused on the effects of a particular computer program on students' learning. This was because the main purpose in the 1960s and 70s for using IT in education was to enhance existing teaching and learning practices or to present the existing curriculum in innovative ways. The research and development of IT in educational settings was therefore intertwined with the design of the IT tools themselves as well as focussing on the impact which these had on students' learning. It also provided feedback for improving the software design.

During the development of IT in education in the last forty years there has also been an extensive growth in educational research generally and in our understanding of the impact of the wider educational experiences on students' learning alongside revolutionary changes in the IT industry itself. Researching the effects of IT on students' learning now includes measuring the consequences of collaborative learning; the increasing autonomy of the learner; the relationship between the immediate learning experience and the wider learning context; the role of the teacher and many other influences. This paper will review the methods and techniques which have been used over the last forty years to research the impact of IT in education drawing on evidence from many previous research studies and their effectiveness as research tools.

1 Introduction

The initial introduction of new technologies (IT/ICT[1]) in education in the 1960s was based on two main thrusts which influenced the early focus of research in this area. Firstly, universities and national bodies recognized the need to provide a growing number of IT experts to work in the IT industry, and secondly pioneering educators saw the potential for new technologies to enhance teaching and learning in other subjects (Beauchamp, 2003, Cox, 2005). Most IT resources were invested into the teaching of Computer Science at University and later at school level rather than using IT to enhance teaching and learning (Rushby, 1983). However, the early research into IT in education focussed on the effects of a particular computer program on students' learning (cf.

[1] For simplicity, I shall use the term IT (information technology) throughout the paper although there are other equally widely used terms for computers and other devices, such as Information and Communications Technologies (ICT) used widely in Europe and Africa for example.

Suppes, 1968, Bork, 1981, Merrill, 1975) rather than the effectiveness of teaching computer science. This was because apart from teaching Computer Science, the main purpose in the 1960s and 70s for using IT in education in many countries was to enhance existing teaching and learning practices or to present the existing curriculum in innovative ways. The research and development of IT in educational settings was therefore intertwined with the design of the IT tools themselves and as well as focussing on the impact which these had on students' learning, it also provided feedback for improving the software design.

There are three main strands which have been shown to be important regarding the impact of IT on education and society (Cox, 2005) resulting in the diversification of educational research in this area:

Technological developments: The developments in IT and associated communications software have led to the migration of IT from industry into education, from university to school, and from commerce into the classroom. As the technology became more widely accessible governments and influential educators initiated programmes of innovation and change concerning the uses of IT in education.

.

Educational initiatives: Major government policies regarding IT in education, in many countries, resulted in programmes to promote and support the teaching and uses of IT in education dating back to the 1960s and 70s. These programmes were enhanced by local government, industrial and commercial initiatives for the education sectors and individual initiatives which have contributed and influenced the growth of IT in education.

Applications to teaching and learning: As IT has evolved with the support of national and international initiatives IT has impinged upon many education sectors. The growth in the IT industry itself has resulted in a relentless growth in the numbers of IT specialists needed to serve this industry. This has led to a rapid growth in IT courses in education both at school and university level and the use of IT to enhance other subjects.

These complimentary developments, alongside the expansion and diversification of the broader field of educational research, have resulted in an evolution of researching IT in education. Research focii have diversified from the early beginnings, with the focus only on the impact on students' learning, to measuring the effects of teachers' pedagogies on IT use and integration (Webb and Cox, 2005), the impact of the institutional culture on the uptake of IT in schools (Fullan, 1991, 2003) the attitudes of teachers and students towards new technologies (Katz and Offir, 1994, Knezek, Miyashita and Sakamoto, 1993, Katz, 2002) and comparisons across different countries (Plomp, Scholtes and Brummlehuis, 1996, Pelgrum, 2001). However, there are still many limitations to the research methods used, the contexts in which such research takes place and the conclusions drawn from research studies (Furr, Ragsdale, and Horton, 2005, Cox and Marshall, 2007). This paper reviews some of the methods and techniques which have been used over the last forty years to research the impact of IT in education drawing on evidence from many previous research studies and their effectiveness as research tools to measure the impact of IT in education.

2 The impact of IT on students' learning

The early educational computing software was either based on tutorial style drill and practice programs following Skinner's theory of programmed learning, or simulations based on Piaget's constructivist learning theories which allowed the learner to investigate hypotheses and explore factorial relationships. These IT programs involved simulating laboratory experiments, which took too long, or were too difficult or costly for students to perform (McKenzie, Elton and Lewis, 1978), or simulating other scientific processes which were, for similar reasons, beyond the scope of the learner using other more traditional learning methods (Cox, 1992). These same educational philosophies were applied to many CAL programs throughout the 1970s, 80s and 90s (Watson, 1992) until IT educational resources enabled larger and more generic applications to be developed such as computer based modelling and on-line learning.

Early research into the impact of computer simulations and modelling on learning by Papert (1980) Kurland & Pea (1983), Cox (1984) and Ogborn & Wong (1984) and many others found that this type of software enabled pupils to conduct investigations of scientific processes, which were otherwise beyond the limits of their mathematical abilities. They could also construct scientific relationships which more accurately represented the world around them. Using examples of existing simulations pupils could carry out investigations taking on the role of scientists, studying processes which were too lengthy, dangerous, or costly to be conducted in the school laboratory. The techniques for measuring the impact of IT on learning included developing and applying pre- and post concept based tests, designing specific scientific paper based tasks which were then assessed and observing and then analysing the specific strategies which students used when working with the materials.

Using these techniques, research conducted by the Tools for Exploratory Learning Project in the UK (Mellar et al, 1994) comparing simulations with framework (modelling) software, showed that pupils were able to investigate much more complex models provided in simulations than to build their own. The Impact project (Watson, 1993), which studied the effects of IT on over 2000 primary and secondary pupils using a range of paper based tests, pre- and post tests, specific tasks and observations found a statistically significant positive impact of IT on children's learning in English, mathematics and geography. This impact however depended upon the nature of the learning tasks and the pedagogical practices of the teacher. The initially allocated experimental and control groups however, changed over the life-time of the three year study so that some of the results did not relate accurately to the actually level of IT use in both groups of classes over the duration of the project (Cox, 1993).

10 years later, the ImpaCT2 project, also in the UK (Harrison et al., 2002) found that there was a statistically significant relationship between the use of IT and National test results for primary pupils (aged 7-11) in English. It was also found that the highest reported use at this age level was in English, with over 61% of the pupils reporting that they used IT in English for at least some weeks in a term. ImpaCT2 also found that for secondary pupils aged 11-14 there was a statistically significant correlation between IT and national test results for science even though the use (31% using it for some weeks)

was less than English (39%) and mathematics (33%). However, only in the case studies did the research team identify the actual types of IT being used so it was not possible to identify the actual type of IT use which had the greatest impact on the pupils' results in the above subjects. (Cox and Abbott, 2004).

There is also a growing body of research evidence related to the motivational effects of IT, showing that IT makes learners' lessons more interesting, more enjoyable, and more important (Cox, 1997, 1999) and increases self-confidence (Gardner, Dukes and Discenza, 1993). Additionally, there is a large psychological literature base on theories and empirical evidence about the attitudinal effects on people's abilities to use IT in the workplace which has implications for teachers' practices and pedagogies (see, for example, Davis, Bagozzi, and Warshaw, 1989, Ajzen, 1988, Ames, 1992, Compeau and Higgins, 1999, Koutromanos, 2005). Most of these studies have involved the use of attitude tests and statistical analyses, although it is not possible in some cases to establish any causal link between the effects of IT and the learner's motivation. Evidence from these studies show that people are more likely to use new technologies if they have a positive attitude towards them and perceive them to be useful in their work and for their professional development.

In addition to the above, specific examples of the positive effects which different types of IT can have on students' learning include:

- using data-logging can develop students' thinking skills (Barton, 1997, Hennessy et al., 2005)
- computer based modelling can enhance students' construction, representation and interpretation of knowledge (Brna, 1990, 1991, Mellar et al., 1994, Taylor et al., 1997, Dori and Barak, 2001, McDougall, 2002, Cox, 2003, Simpson, Hoyles and Noss, 2005);
- using an algebra software system can enhance the learning of mathematics and physics concepts and relationships (Davelsbergh et al., 2000).

Additionally, ICT can enhance students' learning through collaboration:

- in pairs or groups (Watson, et al., 1993, Crook, 2001);
- working together on laptops (Thorpe and Roberts-Young, 2001);
- whole class use with an interactive whiteboard (Cox and Webb, 2004) working together on-line; and
- working on projects and evaluating each other's work (Stacey, 2002, McAlister et al., 2004).

However, the extent of these benefits to learning will depend upon the level of access to IT resources as well as the types being used (van den Akker, Keursten and Plomp, 1992, Scrimshaw, 2004, Ofsted, 2002), the actual types of use, and the teachers' knowledge, beliefs and pedagogical decisions (Laurillard, 1992, Wild and Braid, 1996, Cox, 1997, Webb and Cox, 2004).

The large body of research evidence using a range of research methods now spanning more than 40 years has resulted in some common understandings of the affordances which different IT types can provide for students' learning. Using the table derived by Webb and Cox (2005) shown below (Table 1) it is clear that the potential beneficial impact of IT on individual students' learning is firstly very dependent upon the level of access, and secondly upon the specific types of IT use whether in school, university or at home. In parallel with a large number of studies of the effects of specific types of IT use on students' learning in many countries (Watson and Anderson, 2002, Marshall and Katz, 2003) there have been since the mid-1980s studies on the uptake and use of IT in many different educational settings which are discussed in the next section.

Table 1 Affordances for students' learning (Webb and Cox, 2005)

Categories of affordances	**Learning supported**	**Type of IT used**
Researching information	Acquiring knowledge, consolidating understanding	Internet, Web browsers, Web cams, Video conferencing, content-specific CD-ROMS
Preparing presentations and producing materials	Organising ideas, reflecting, reviewing, evaluating, consolidating understanding	PowerPoint,
Presenting	Presentation skills, organising ideas, reflecting, reviewing, evaluating	PowerPoint, Interactive Whiteboard,
Visually representing processes / ideas	Understanding dynamic processes	Simulations, animations
Feedback	Knowing what areas need more learning, Thinking, Predicting,	Simulations, Mind mapping software, Interactive Whiteboard
Changing variable values	Understanding relationships between variables, Predicting, Hypothesising	Simulations, Spreadsheets
Brainstorming	Thinking, Linking ideas	Interactive Whiteboard, Mind mapping software
Redrafting	Organising ideas, reflecting, reviewing,	Word processors, Interactive Whiteboard,
Recording notes	Thinking about relationships	Word processors, Interactive Whiteboard,
Designing	Problem solving, Decision making	Control software
Making a drawing	Thinking about what they already know about composition	Drawing package
Taking turns	Social skills, sharing	Roamer, shared computer
Broadening experience	Generalising from examples, extending their ideas, classifying, generating new ideas	Internet, Web browsers, Web cams, Video conferencing
Drawing graphs	Thinking about relationships between variables	Spreadsheets

3 Research into IT uptake and use in education

As computers and IT resources became more widespread in the 1980s, as explained above, many studies of the impact of IT on learning discussed above also showed that the level of such impact and the possible benefits to learning were very dependent upon the actual availability of IT resources in schools and other educational settings. The first

issue facing governments and educators is the conflict between teaching and learning of IT as a subject to produce IT experts for tomorrow's world, and the application and use of IT within all curriculum subjects to enhance the learning of traditional concepts and skills in education. For the former, this requires only a subset of teachers adequately trained and qualified in IT, and enables schools to assign limited IT resources to one curriculum subject only. For the latter, this requires all teachers to have expertise in using IT effectively in their own subjects as well as knowledge of how the use of IT will extend and enhance their pupils' learning beyond those achievable through traditional methods, and more extensive IT resources. To achieve this, all school teachers need extensive training not only in new pedagogical practices but in understanding the new literacies of IT.

Since the 1960s there have been more than 10 Worldwide International Statistical Comparative Educational Assessments in education (Pelgrum and Plomp, 1993, Pelgrum and Anderson, 2001) which have involved large scale quantitative surveys and tests some of which have focussed on IT in education. These studies have enabled different countries to determine what their status is regarding for example, the relative investment in school IT resources, the level of teacher training and the use of IT in different subjects. The advantages of such studies are that the instruments are developed and piloted by a large team of researchers for use in different educational settings and countries ensuring a high level of consistency and reliability. The research data from these international studies enable researchers and policy makers to assess their own achievements regarding IT in education and the relative effectiveness of their past policies. It is more difficult however to determine the effects of IT on teaching and learning in relation to other countries because of the widely varying national priorities. For example, as explained above, the different balance between using IT in schools to enhance teaching and learning and teaching it as a separate subject will affect the way IT is used in education and the pedagogies of the teachers (Cox, 2005).

In the UK, biennual surveys have been done by the Department of Education and Science (now Department for Education and Skills) e.g. in 1985/6, 1987/8, 1989/90 and 1991/2 to assess the impact of government initiatives on the uptake and level of use of computers in British schools. From the results of such surveys (DES, 1991) it is possible to see the changes which have taken place over a specific period, e.g. from 1985 to 1991 and how these have affected the actual uptake and use by teachers in schools. Similar surveys have been conducted in many countries and one common finding is that the actual integrated use of IT by teachers is much lower than had been expected as a result of so may sustained national and international programmes (Cox and Abbott, 2004). What makes the uptake and integration of IT so difficult is that it is extremely complex for teachers to learn, is always changing and as explained earlier will depend upon so many different curriculum priorities

One aspect of the Impact2 study was on the informal uses of IT, outside of school. There have been a growing number of studies of the uses of IT by children in both formal and informal contexts. Yelland (2003) investigated 20 children's formal and informal experiences using computer games in mathematical contexts. She studied the ways in which children chose and evaluated computer software in the home and at school. This

type of study using qualitative methods of observation and interviews is widely used by researchers of IT in education but has been criticised because of the limited applicability of the outcomes to the wider population of learners (Cox and Marshall, 2007). A larger study on young people's home and school IT use was conducted by Kent and Facer (2004) which involved a questionnaire survey of 1800 children in South West England, interviews of 190 children and visits to 11 families. The focus of the study was on computer use and not on the consequent impact on students' learning. Although governments are anxious to know how widely IT resources are being used, such studies do not give any information about whether such specific uses of IT might benefit the learner more than other which they have not chosen to use.

There are still many unanswered questions about the benefits to children of using IT outside formal school settings. What is more widely known is that the effectiveness of IT use in formal settings such as schools and colleges is very dependent upon the teacher.

4 Researching the impact of the teacher

When IT was first introduced in education, as explained above it was not understood that its effectiveness would be significantly determined and in many cases restricted by the beliefs, attitudes and practices of the teachers. Therefore, in spite of there being encouraging evidence of IT's contribution to students' learning, a large area of educational research has also evolved to investigate how IT effects the ways in which we teach using IT (cf. Cox and Webb, 2004, Law and Plomp, 2003), the pedagogical beliefs and practices of teachers (Webb, 2002, Cox and Webb, 2004) the enablers and barriers to the use of IT in education (Scrimshaw, 2004, Jones, 2004) and the impact on practice of the professional development of teachers.

In several studies of educational change in schools in America, Canada and the UK, Fullan (1991, 2003) found that one of the most fundamental problems is that people do not have a clear and coherent sense of the reasons for educational change, what it is or how to proceed. Previous research into innovation and change has shown that the adoption of new technologies in education is a complex process involving theoretical, practical and reflective engagement (Hargreaves and Fullan, 1992). This includes the professional development of teachers which both changes and is changed by the organizational context in which it takes place (Sparks and Loucks-Horsley, 1990, Desforges, 1995).

Previous empirical and theoretical research has shown that teachers' knowledge and beliefs about how students learn will significantly affect how they approach and deliver teaching (e.g. Shulman, 1987, Brown et al., 2001, Moore, 2004), including when using IT (Crook, 2001, Webb, 2002). There is also evidence of possible discrepancies between the beliefs of teachers and the research findings regarding effective pedagogy with IT (e.g. Pedretti et al., 1998, Moseley et al., 1999, Scrimshaw, 2004). Scrimshaw (ibid.) identified a recurring contrast regarding IT use between "teacher-centred and student-centred models of teaching". Researchers have also shown that teachers' beliefs are resistant to change because they are deeply rooted in their own experiences and are usually unconscious (Pajares, 1992, Yerrick et al., 1997) and changes in belief follow rather than

precede changes in behaviour (Fullan, 1991). These complex interrelationships between beliefs and pedagogical change in relation to IT use may explain the limited uptake of IT use so far by teachers in schools and the limited impact of continuing professional development (CPD) to date on teachers' ability to adopt IT in their teaching.

5 The effects of teachers' professional development

There are many studies that have shown that once teachers have finished their initial training they do not expect to need much further training and therefore do not take the initiative to improve their practice and learn new skills. Desforges (1995), in a literature review of the shift from novice to expert teachers, found that "many teachers are perfectly well satisfied with their practices and are unlikely to question prevailing educational processes". According to Desforges, in order for teachers to make changes to their professional practice "a considerable effort is necessary to create the possibilities of restructuring knowledge (about teaching and learning) in the face of experience. Furthermore, he maintains that 'in regard to old knowledge we can speculate that the impact of new experience (e.g. using IT) will be severely attenuated if it is in conflict with teachers' basic ontological categories, e.g. their beliefs about the nature of their job or the nature of childhood". Therefore, if teachers see no need to change or question their current professional practice they may not take-up the use of IT in their teaching in spite of receiving additional IT training.

Previous empirical studies (see, for example, Cox, 1994, Rhodes, 1999, Downes et al., 2001) have shown that short courses to train teachers in the uses of IT have mostly focused on the technical aspects of IT with little training about the pedagogical practices required and how to incorporate IT into the curriculum. In many IT professional development courses, teachers are usually not taught how to revise their pedagogical practices, how to replace other traditional lessons without depleting the curriculum coverage and so on. This means that after teachers had attended short courses such as these they still did not know how to use IT for teaching pupils, they only knew how to run certain software packages, how to format disks, or how to print documents.

Much research by Fullan (1991), Scrimshaw (2004) and Cox and Webb (2004) and others has shown that the most effective way to bring about the adoption of an innovation in schools is to engage the whole school in a democratic process of planning change. This means that all the teachers are involved in the decision to adopt IT in the school and are supportive of any individual teacher going on a course and willing to learn from their new knowledge and skills when they return. For the majority of teachers one of their first priorities is to maintain order in the classroom and to have a controlled learning environment. Any suggestion of adopting particularly innovative teaching techniques, such as using IT, is therefore seen as threatening this orderly pattern and therefore not desirable. As a result there is a genuine fear amongst many teachers about IT and scepticism of its value to their pupils. These issues are difficult to research and often overlooked when evaluating the uptake of IT in education.

According to the theory of planned behaviour (Ajzen, 1991), human behaviour, e.g. the use of IT. is guided by beliefs about: the likely outcomes of the behaviour; the normative expectations of others; and the presence of factors which may facilitate or impede the performance. The attitudes of teachers towards IT, and their willingness and ability to use

IT have been reported in a range of empirical studies. An investigation into the effects of attitudes on the use of IT and its perceived value to the users revealed a significant relationship between the IT abilities of the teacher and their perceived value of ICT to pupils' learning. (Preston, Cox & Cox, 2000).

From these and many other similar results it is evident that researching the impact of IT in education requires: an understanding of the complex nature of IT itself; the development and use of relative theories which underpin psychological and sociological aspects relating to the teacher, the learner and the educational settings; and research methods which take account of the complexity of the variables which might affect any specific study. Furthermore, IT is not a static technology, so researchers need to keep abreast of technological developments and how these might affect education.

6 The slippery technology and changing perceptions and practices

As mentioned earlier in the paper, one of the major factors which makes researching IT in education so interesting but extremely difficult unlike many other educational changes is the ever changing technology itself which continues to be embraced under a single heading of "new technologies" or IT or ICT in education. Table 2, developed from an earlier one published in 2005 (Cox, 2005) shows just how many changes have occurred in the last 10 years in the field of computer technologies.

Table 2 - The evolving IT technology (derived from Table 2, Cox, 2005)

Dates/era	Technological developments
1822 - 1833	Invention of the difference engine for calculating large mathematical numbers, the forerunner of computers, by Charles Babbage
1837 - 1896	The introduction of the telephone, cables and communications technologies
1950 - 1967	Development of large scale main-frame valve based analogue computers Development of miniature electronic components (transistors and diodes) and circuitry leading to the large scale digital computer Increase in memory and processing capacity
1968	The introduction of the Internet - ARPANET – JANET
1970 - 1977	Development of real-time interactive computers User graphics on-line computer terminals available at £5000 Internet connections for some schools Remote access to computers from different locations International networks of computers through JANET Forerunners of desk-top computers: e.g. Hewlett Packard, Horizon
1977 - 1980	Miniaturization of computers - Production of small desk top computers: Horizon - £5000, Apple II - £1000, RML 380z £2000, IBM series - £2000 Acorn atom computer, Acorn BBC - Model A (8k of memory) Acorn BBC model B (32k of memory) - £400 Move from tape-based storage to disk based storage of computer programs Prestel/Teletext – commercial and educational information provided on-line

1980 - 1984	First Apple-Macintosh produced - £1500 Development of fibre optics facilitating fast and large scale communication Development of a range of input and output devices for education, including: Concept keyboard/graphics tablets Quinkey keboard Robot turtle Tracker ball Touch screens Speech input and output
1985 - 1987	Microsoft windows launched More powerful cheaper personal microcomputers IBM PC – (256k of storage memory, 32k processor) $1500 Mac II – (256k of storage memory, 32k processor) $1000 Invention of the World Wide Web by Tim Berners-Lee
1987 - 1990	New external storage devices CD-ROM Interactive video Plug-in memory cards
1990 - 1995	Introduction of lap-top computers Major increase in storage memory devices and reduced costs (> 1Gbyte for $70) Spread of wireless computer technologies Wireless computer networks Air-mouse Development of video-conferencing
1996 - 1999	Development of the electronic whiteboard Introduction of Personal Digital Assistants (PDAs) Universal growth of the uses of the Internet in education
2000 - 2004	Expansion of mobile hand-held technologies: PDAs, Mobile phones, MP3 players Development of molecular computing technology Development of quantum computers Further increases in processing and storage of personal computers (5G storage memory, >256k processor)
2005 - 2007	Thin client technologies in schools and colleges Development of haptics devices for use in education. Development of molecular computing technology Development of quantum computers Further increases in processing and storage of personal computers and minituarization (10G storage memory, >256k processor) Widespread access to wireless networks Web2 technology

As a result of this ever-changing technology, new literacies (perceptions and understandings linked to new modes of presentation and representations) are changing the emphasis and the balance in terms of the production, content and meaning of educational resources, which is often not understood by teachers and researchers. These changes often require a recodifying and consequent new understanding of knowledge, and the change in teacher-pupil relationship caused by the autonomous nature of many IT-education environments. These lead to a conflict for the teacher and the

learner regarding whether to stagnate in the use of IT by confining oneself to simple comfortable uses or whether to open up the use to the wide range of technologies which arrive in society at an alarming rate.

These conflicts facing education require a substantial change in the ways in which teachers are trained to use new technologies, changes in the formal school curriculum, as well as a reorganisation of curriculum time, teachers' professional development, home-school links and pedagogical practices within educational institutions.

7 Conclusions

Forty years on from researching the effect of small computer programs on students' learning of simple mathematics concepts, we now have a mountain of IT resources ranging from computers on desks to wireless mobile devices which individual learners can carry and use 24/7. We also have massive evidence about the impact of some types of IT on teaching and learning. The research methods have changed to embrace both quantitative and qualitative techniques which are often used in an eclectic mix according to the research aims. These diverse research approaches have been criticised in recent years for failing to take account of the theoretical background of the research methods and conceptual frameworks (Yanchar and Williams, 2006). This particularly applies to the field of researching IT in education.

Whereas in many other areas of education, the resources being used are under the control of the teacher, the rapid growth of IT in society has resulted in governments prioritising IT in education and wanting rapid answers to its potential for teaching and learning. Yet one important lesson to date from the studies reviewed here is that it takes a long time to measure the impact of IT on teaching and learning and many teachers are reticent about using IT substantially in their curriculum. This is at odds with the constant pressure from governments to obtain quick answers to what is a very complex educational environment.

Researchers of IT in education themselves come from diverse backgrounds, some with an IT strength emanating from computer science, some with an artificial intelligence background based on psychological theories and some with a sociology background relating to the institutionalisation and cultural influences on IT education. What is evident from this review is that without a clear understanding of the complex nature and power of IT it is difficult to develop the appropriate methods and theories to conduct robust research studies. These difficulties are offset to some extent by the international nature of IT in education with many common developments and a sharing of research approaches and results.

In spite of the complex nature of IT there has been in recent years a number of studies discussed above which have included the development of educational theories which can underpin educational research. These include Ajzen's theories of reasoned action and planned behaviour (1988), Louck et al.'s (1998) level of use model and Cox and Webb's (2004) pedagogical model. There are many other theories now being used to underpin research in IT in education and which will enable more consistent and repeatable research to be achieved. What is needed now is more research into the effectiveness of different

research techniques across different cohorts of learners for different types of IT in relation to these theories.

References

Ajzen, I. (1988) *Attitudes, Personality and Behavior*. Open University Press. Milton Keynes.

Ames, C. (1992) *Classroom; goals, structures and student motivation*. Journal of Educational Psychology. Vol. 84 (3) 261-271

Barton, R. (1997). *Does data-logging change the nature of children's thinking in experimental work in science? Using information technology effectively in teaching and learning*. In B. Somekh and N. Davis. (Eds.) London, Routledge: 63-72.

Beauchamp, A.P. (2003) *An Investigation into IT in the Secondary School Curriculum: Servant or Subject?* Doctoral Thesis. University of London

Bork, A. (1981). *Learning with computers.* Billerica, MA: Digital Press. United States

Brna, P. (1990) *A methodology for confronting science misconceptions.* Journal of Educational Computing Research, 6, 157-182.

Brna, P. (1991) *Promoting creative confrontations.* Journal of Computer Assisted Learning, 7, 114-122.

Brown, M., Askew, M., Rhodes, V., Ranson, E., Denvir, H.& Wiliam, D. (2001). *Magic Bullets or Chimeras? Searching for Factors Characterising Effective Teachers and Effective Teaching in Numeracy.* British Educational Research Association Annual Conference Symposium on Pedagogy and educational policy: modernising teaching or narrowing the agenda. University of Leeds.

Compeau, D. R., & Higgins, C. A. (1999). *Social cognitive theory and individual reactions to computing technology:* A longitudinal study, MIS Quarterly, 23: 145-158.

Cox, M.J. (1984) .*Evaluation and Dissemination of Science Software*. Journal of Science Education in Japan, Vol. 8 (2)

Cox, M.J. (1992) *The Computer in the Science Curriculum.* in Plomb,T.J. & Moonen, J. (Eds.) The International Journal for Educational Research. Vol 17(1). Elsevier Science Publishers B.V. Netherlands.

Cox, M.J. (1993) Te*chnology Enriched School Project - The Impact of Information Technology on children's Learning*. Computers Educ. Vol. 21, No1/2, pp 41-49

Cox, M.J. (1997) *The Effects of Information Technology on students' motivation.* Final Report. NCET/King's College London 1997. ISBN 871984-28-9

Cox, M.J. (1999) *Motivating pupils through the use of ICT*. in Leask, M. & Pachter, N. (Eds.) Learning to Teaching using ICT in the Secondary School. Routledge. 1999. 19-35

Cox, M.J. (2003). *How do we know that ICT is having an impact on children's learning? A review of techniques and methods to measure changes in pupils' learning promoted by the use of ICT.* in Marshall, G. & Katz, Y. Learning in School, Home and Community:

ICT for Early and Elementary Education. Kluwer. Netherlands. pp 159-168 ISBN 1-4020-7367-4

Cox, M. J. and Abbott, C. (Eds.), *ICT and attainment – a review of the research literature. Full Report.* Becta Coventry/DfES London January 2004 http://www.becta.org.uk/research/index.cfm

Cox, M. J. and Webb, M. (2004) (Eds.), *ICT and pedagogy – a review of the research literature. Full Report* Becta Coventry/DfES London January 2004 http://www.becta.org.uk/research/index.cfm

Cox, M.J. (2005) *Educational Conflict: the problems in institutionalizing new technologies in Education* In Kouzelis, G., Pournari, M., Stoeppler, M., Tselfes, V. (Eds.) Knowledge in the New Technologies Peter Lang. Frankfurt, Berlin, Bern, Bruxelles, New York, Oxford, Vienna. ISBN 3-631-53782-4 March. 2005 pp 139-165

Cox, M.J. & Marshall, G.M. (2007) *Effects of ICT: do we know what we should know?* Education and Information Technologies Vol. 12 (1)

Crook, C. (2001). *The social character of knowing and learning: implications of cultural psychology for educational technology*. Journal of Information Technology in Teacher Education. Vol. 10, Nos. 1 &2, pp19-36.

Davelsbergh, E. R., de Jong, T., & Ferguson-Hessler, M.G.M (2000). *Learning physics with a computer algebra system*. Journal of Computer Assisted Learning Vol. 16(3): 229-242.

Davis, F.d, Bagozzi, R.P & Warshaw, P.R. (1989) *User acceptance of computer technology: a comparison of two theoretical models*. Management Science. Vol 35(8). 982-1003

Department for Education and Science (1991). *Results of the Survey of information and Technology in Schools.* Statistical Bulletin. Issue No. 11/91. London. The Stationery Office

Desforges, C., (1995) *How does experience affect theoretical knowledge for teaching. Learning and Instruction*, 5, 385-400.

Dori, Y. J. & M. Barak (2001). *Virtual and Physical Molecular Modeling: Fostering Model Perception and Spatial Understanding*. Educational Technology and Society Vol. 4(1).

Downes, T., Fluck, A., Gibbons, P., Leonard, R., Matthews, C., Oliver, R., Vickers, M., and Williams, M., (2001) *Making Better Connections: Models of Teacher Professional Development for the Integration of Information and Communication Technology into Classroom Practice. A Report to the Commonwealth Department of Education, Science and Training.*, Canberra, Australian Curriculum Studies Association.

Fullan, M.G., (1991) *The new meaning of Educational Change*. London, Cassell.

Fullan, M.G. (2003) Change Forces with a Vengeance. Routledge Falmer, London and New York.

Furr, P.F., Ragsdale, R. & Horton, S.G. (2005). *Technolopg's non-neutrality: past lessons can help guide today's classrooms*. Education and information Technologies 10:3, 277-287

Gardner, D.G., Dukes, R.L. Discenza, R.(1993) *Computer use, self-confidence, and attitudes: a causal analysis.* Computers in human behaviour. Vol 9. pp 427 -440

Hargreaves, A. & Fullan, M. G., (1992) Introduction in Hargreaves, A. and Fullan, M. G., *Understanding teacher development*, New York, Teachers College Press, 1-19.

Harrison,C., Comber,C., Fisher, T., Haw, K., Lunzer, E., McFarlane, A., Mavers, D., Scrimshaw, P., Somekh, B. and Wating, R. (2002) ImpaCT2 *The impact of Information and Communication Technologies on Pupil Learning and Attainment.* BECTa and DfES. DfES publications.

Hennessy, S., Ruthven, K., & Brindley, S., (2005) *Teacher perspectives on integrating ICT into subject teaching: commitment, constraints, caution and change*. Journal of Curriculum Studies, **37,** 155-192.

Johnson, D.C. & Samways, B. (1993) Informatics and Changes in Learning. Proceedings of the IFIP TC3/WG3.1/WG3.5 Open Conference, Gmunden, Austria, 7-11 June 1993

Jones, A., (2004) *A review of the research literature on barriers to the uptake of ICT by teachers.*, Coventry and London, Becta / DfES.

Katz, Y. J. and B. Offir. 1994. Computer Games as Motivators for Successful Computer End-Use. In *Exploring a New Partnership: Children, Teachers and Technology*, Amsterdam: Elsevier Science Publ B V.

Katz, Y. J. (2002) *Attitudes affecting college students' preferences for distance learning* Journal of Computer Assisted Learning 18 (1), 2–9.

Kent, N. & facer, K. (2004) *Different worlds? A comparison of young people's home and school ICT use*. Journal of computer assisted Learning. 20 (6) 440-455

Knezek, G., Miyashita, K., and Sakamoto, T. (1993). *Scaling item response descriptors for the YCCI Technical Report 93.6* for Studies on Children and computers 1993-94 Series. December 1993

Koutromanos, G., (2005) *The effects of head teachers, head officers and school counsellors' attitudes on the uptake of Information technology in Greek schools*. PhD Thesis. King's College London. University of London

Kurland, D.M., & Pea, R.D. (1983) *Children's mental models of recursive LOGO programs*. in Proceedings of the Fifth Annual Cognitive Science Society. Rochester, New York.

Laurillard, D., (1992) *Phenomemographic research and the design of diagnostic strategies for adaptive tutoring systems* in M. Jones & Winne, P., Adaptive learning environments: Foundations and frontiers, Berlin, Springer-Verlag, 233-248.

Law, N., & Plomp, T. (2003). Curriculum and Staff Development. In T. Plomp, R. Anderson, N. Law & A. Quale (Eds.) *Cross-national Policies and Practices on Information and Communication Technology in Education*. Information Age

Loucks, S. F., Newlove, B. W., & Hall, G. E., (1998) *Measuring levels of use of the innovation: a manual for trainers, interviewers and raters*, Southwest Educational Development Laboratory.

McAlister, A., Ravenscroft, A., & Scanlon, E. (2004). *Combining interaction an context design to support collaborative argumentation using a tool for synchronous CMC.* Journal of Computer Assisted Learning. 20(3) pp. 194-204

McDougall, A. (2002) *Technology-Supported Environments for Learning through Cognitive Conflict.* Association for Learning Technologies Journal ALT-J, 10:3, 83-91

McKenzie, J., Elton, L.R.B., & Lewis, R. (1978) (Eds) *Interactive Computer Graphics in Science Teaching.* Ellis Horwood. Chichester.

Mellar, H., Bliss, J., Boohan, R., Ogborn, J., & Tompsett (Eds.) (1994) *Learning with Artificial Worlds: Computer Based Modelling in the Curriculum*. The Falmer Press. London.

Merrill, P.F. (1975) *The role of computer technology in an open learning environment.* Proceedings of the Second National Conference on Open Learning and Non-traditional Study. 323-326

Moore, A. (2004). *The good teacher: Dominant discourses in teaching and teacher education.* Routledge-Falmer. London and New York.

Moseley, D., Higgins, S., Bramald, R., Hardman, F., Miller, J., Mroz, M., Tse, H., Newton, D., Thompson, I., Williamson, J., Halligan, J., Bramald, S., Newton, L., Tymms, P., Henderson, B., & Stout, J., (1999) *Effective pedagogy using ICT for literacy and numeracy in primary schools*, Newcastle, University of Newcastle.

OFSTED. (2002) *ICT in schools: effects of government initiatives. Progress Report* April 2002. HMI 423. London. Office for Standards in Education.

Ogborn, J. & Wong, D. (1984) *A microcomputer dynamic modelling system.* Physics Education. Vol. 10. pp 138-142

Pajares, F., (1992) *Teachers' beliefs and educational research: Cleaning up a messy construct.* Review of Educational Research, 62, 307-332.

Papert, S. (1980). Mindstorms: *Children, computers, and powerful ideas*. New York: Basic Books.

Pedretti, J. E., Mayer-Smith, J., & Woodrow, J., (1998) *Technology, Text, and Talk: Students' Perspectives on Teaching and Learning in a Technology-Enhanced Secondary Science Classroom*. Science Education, 82, 569-590.

Pelgrum, W.J. & Plomp, T. (1991) *The Use of Computers in Education worldwide. Results from the IEA Computers in Education Survey in 19 Education Systems.* Pergamon Press. Oxford, UK.

Pelgrum, W. J. (2001). *Obstacles to the integration of ICT in education: results from a worldwide educational assessment.* Computers & Education Vol.37 (2) pp.163-178.

Pelgrum, W. J. & Andersen, R. E. (2001) *ICT and the emerging paradigm for life-long learning: an IEA educational assessment of infrastructure, goals and practices in twenty-six countries.* Amsterdam. International Association for Educational Achievement.

Plomp, Tj., Scholtes, E. & Brummelhuis, A.(1996) *Policies on computers in education in the Netherlands*. In *Cross National Policies and Practices on Computers in Education*. (pp. 359 - 380). Dordrecht : Kluwer Academic Publishers.

Rhodes (1999). *IT in Primary Schools: the rhetoric and the reality, supporting teachers in the process of implementation*. PhD Thesis. University of London

Rushby, N.J. (Ed.) (1983) *Computer Based Learning - State of the Art Report.* Pergamon. New York

Shulman, L., (1987) *Knowledge and teaching: Foundations of the new reform*. Harvard Educational Review, 57, 1-22.

Scrimshaw, P., (2004) *Enabling teachers to make successful use of ICT*, Coventry, British Educational Communications and Technology Agency (Becta).

Simpson, G., Hoyles, C. & Noss, R. (2005). *Designing a programming-based approach for modelling scientific phenomena*. Journal of Computer Assisted Learning. 21 (2) 143-158

Sparks, D. & Loucks-Horsley, S., (1990) *Models of staff development* in Houston, W. R., Haberman, M., and Sikula, J., *Handbook of research on teacher education*, New York, Macmillan, 234-250.

Stacey, E. (2002).*Social Presence on-line: networking Learners at a Distance.* In Watson, D. & Andersen, J. (Eds.) Networking the Learner: Computers in Education. Dordrecht. The Netherlands. Kluwer Academic Press. pp 39-48

Suppes, P (1968) *Computer-assisted instruction: an overview of operations and problems*. IFIP Congress (2) 1968: 1103-1113

Thorpe, R. & Roberts-Young, D. (2001). *Portable Computers: a catalyst for collaboration? A study of How the Use of Multimedia Portable Computers in Primary Schools Can Affect Teacher and Pupil Collaboration*. Journal of Information Technology for Teacher Education 10(3): pp.203-223.

van den Akker, J., Keursten, P., & Plomp, T., (1992) *The Integration of computer use in Education*. International Journal of Educational Research, 17.

Watson, D.M. (1992) *The Computer in the Social Science Curriculum* in Plomb,T.J. & Moonen, J. (Eds.) The International Journal for Educational Research. Vol 17(1). Elsevier Science Publishers B.V. Netherlands.

Watson, (Ed.) (1993) *The ImpacT Report - An evauation of the impact of Information technology on children's achievements in primary and secondary schools.* King's College London.

Watson, D. M. & Anderson, J. (2002) (Ed.) *Networking the Learner*. Computers in Education. IFIP. Kluwer Academic Publishers. Dordrecht. The Netherlands.

Webb, M. E., (2002) *Pedagogical reasoning: issues and solutions for the teaching and learning of ICT in secondary schools*. Education and Information Technologies, 7, pp.237-255.

Webb, M. & Cox, M.J. (2005) *Teachers' peedagogical decision making in relation to the uses of ICT for learning and teaching*. Paper presented at the International Federation for Information Processing (IFIP)'s World Conference on Computers in Education (WCCE2005). Stellanbosch. South Africa. July 2005.

Wild, M. & Braid, P., (1996) *Children's talk in co-operative groups*. Journal of Computer Assisted Learning, 12, 216–231.

Yanchar, S. & Williams, D.D. (2006) *Reconsidering the compatibility thesis and eclecticism: five proposed guidelines for method use*. Educational Researcher Vol. 35 (9). 3-12

Yelland, N. (2003) *Learning in school and out: formal and informal experiences with computer games in mathematical contexts:* in Marshall, G. & Katz, K. (Eds.) Learning in school, home and community: ICT for early and elementary education. Kluwer Academic Publishers. Boston/Dordrecht/London. 3-12.

Yerrick, R., Parke, H., & Nugent, J., (1997) *Struggling to promote deeply rooted change: The filtering effect of teachers' beliefs on understanding transformational views of teaching science.* Science Education, 11, 147-159.

Paper 2

Global Interdisciplinary Research Into The Diffusion Of Technology Innovations In Education

Niki Davis
Iowa State University Center for Technology in Learning and Teaching
nedavis@iastate.edu

Introduction

Interdisciplinary research into the diffusion of innovations has been led by Everett Rogers (2003) over the past four decades, starting with the seminal study of agricultural innovation in Iowa during his doctoral studies at Iowa State University. Little of that research has touched TACITL, so Niki Davis has spent her recent sabbatical leave studying Rogers' work and gathering research and theories relevant to TACTILE with support from scholars including IFIP colleagues. A review of that research will be presented using four perspectives. The perspectives on the diffusion of information technology innovations in education start with a global systems perspective then move to encompass the organization and the change agent before adopting the closest to us all, the individual. Each perspective will be illustrated with both theoretical models and research studies, including those by the author over several decades. These multiple perspectives also have the potential to increase the quality of research by clarifying variables, feedback loops, cycles, and units of analysis.

This paper takes a systems approach to review what is known about change with IT in education. Systems perspectives are developed in layers starting with educational systems globally and then zooming in through layered perspectives and models of change for a school, an individual teacher, and finally the innovation itself. The diffusion of IT in education is influenced by communication within and between the layers. There is evidence that the principal, teacher, and IT coordinator all have key roles in educational leadership of IT. Educational agencies and industrial partners at regional, national, and international levels are also influential. Readers who adopt Senge's (1990) 'systems thinking' will be able to make the best use of the change models, research, and illustrations of successful and failed pedagogical innovations for K-12 schools and teacher education. In addition, simultaneous renewal of organizations is considered because the loosely coupled nature of educational systems requires that multiple organizations change together. These include virtual organizations that have recently emerged to increase access in education, such as K-12 virtual schools.

There is a confusing variety of research in change with IT in education. Reviews of the change literature by Ferster (2006) and Surry (1997) noted that the interdisciplinary literature on diffusion of innovations tends to be deterministic focusing on innovation primarily from the perspective of those who want the innovation adopted (e.g. to market

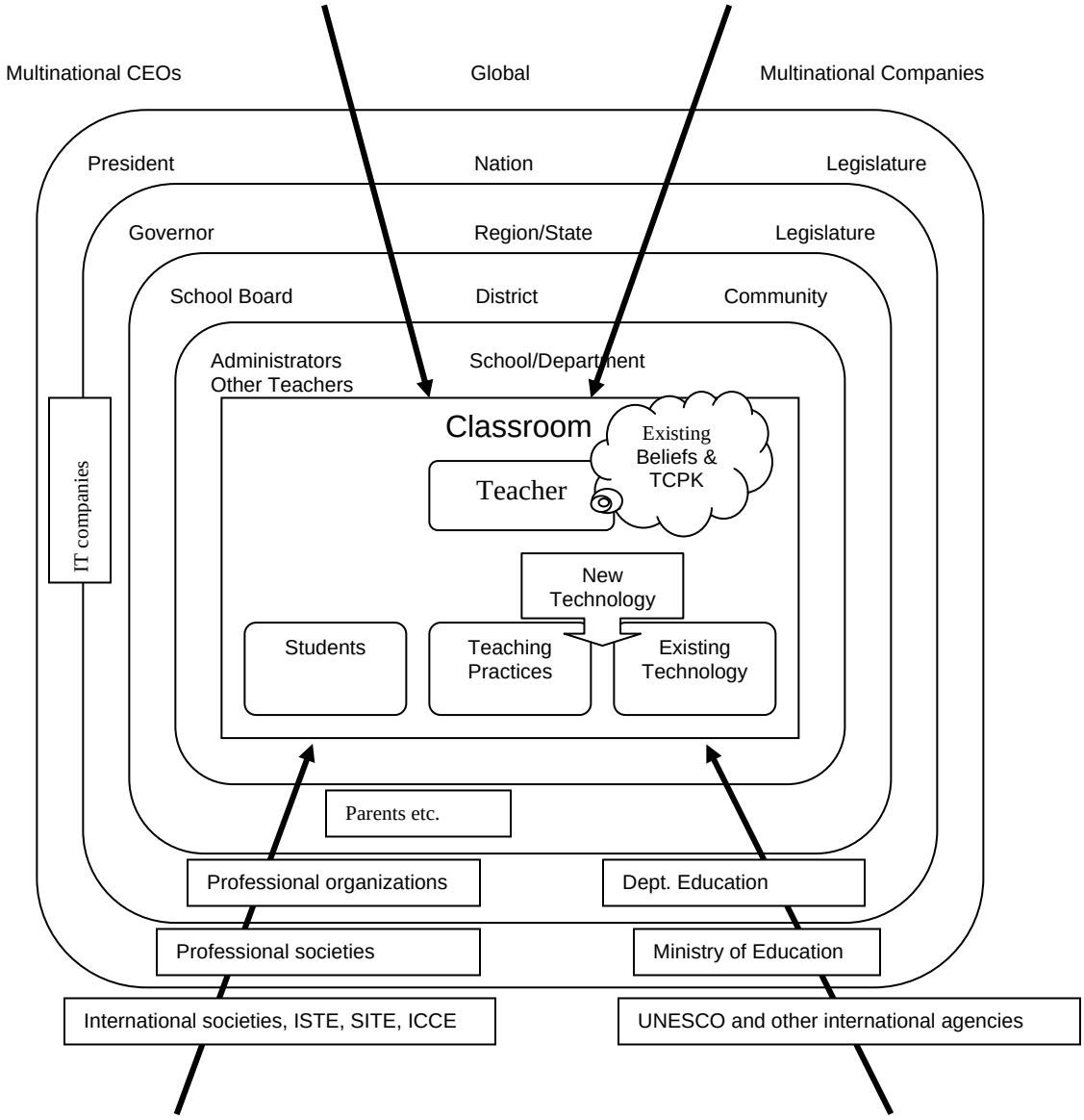
software), whereas that from aspecific educational perspective tends to be more instrumentalist by taking the perspective of the educator considering adoption. Both perspectives are valid and it appears that an approach that recognizes complex and chaotic change is necessary. The next section starts with the largest unit of analysis, a global perspective, and the discussion aims to represent both deterministic and instrumentalist views.

A global perspective on change with IT in education

One way of visualizing change in the complexity of multiple organizations and related communities is to adopt an ecosystems perspective that ecologists have developed to analyze the living world. Figure 1 lays out a layered systems perspective of education with the international organizations and participants at the edge, layers progressing towards the center with the teacher, and the innovation that the teacher may adopt or reject. Figure 1 has been informed by Zhao & Frank (2003: 815) in which "a classroom is nested within multilevel ecological hierarchy including government agencies, societal institutions, local community organizations, and the school bureaucracy". In addition, I have used Fullan's (2001) and Somekh's (2008, accepted) holistic perspectives for the local, regional, and national levels and extending it with my understanding of international agencies, educators' professional organizations, and commercial providers.

Educational researcher Yong Zhao and ecologist Kenneth Frank provided evidence for their ecological framework in which IT (or computer use) used by a teacher was conceptualized as an 'invasive exotic species' interacting and displacing a traditional teacher as a keystone species in the classroom of a school system in favor of an innovative teacher who uses information technology (IT). Zhao & Frank tested ecologists' modeling analysis on uses of IT over time in a 'contained educational system' of 19 schools in 4 districts in the US. They found evidence of co-evolution of both IT and teachers' pedagogies. Change was more likely when there was an 'empty niche', e.g. telecommunications was exploited to communicate with parents, where there had been little communication before. However, IT was rarely exploited for curriculum purposes where it competed with existing curriculum activities. This systemic framework complements Learning/Adoption Trajectory Model's stage of teacher as leader, who, has co-evolved with IT, has a strong influence on local teachers' adoption/evolution with IT (Sherry et al, 2000; Sherry, 2002). Zhao and Frank identified four basic mechanisms that support teacher adoption of IT in the school system: recruitment/selection of new teachers with IT among selection criteria; training/socialization supportive of IT; the provision of opportunities to explore and learn with IT; and leveraging change through the social context including opinion leaders. Their recommendations including consideration of IT during hiring, providing time and support for exploration and learning about IT in the curriculum, and management of the influence of peers (both for and against innovation) and stress caused by competing innovations. These are coherent with Rogers' (2003) seminal work on the diffusion of innovations. At the program level, Zhao and Frank explain why professional development for individual teachers outside school does little to support innovation, whereas group or whole school initiatives that are coherent with the school's strategic plan and supported by its leadership promote technology diffusion.

Figure 1. A global perspective on change with IT in education (developed from Zhao & Frank, 2003 by the author)



My criticism of Zhao and Frank's systemic framework is their misleading use of the term 'extinct'. A teacher who adapts his or her practice to adopt IT does not become extinct, after all the teacher remains; what has occurred is that teachers plus their leaders and supporters, have adapted both pedagogical and organizational practices with the diffusion of IT innovations into education. The term adaptation is a more accurate term. However, Zhao & Frank's (2003) negative analogy of the introduction of zebra mussel into the Great Lakes is a useful negative analogy, to balance the predominantly over optimistic communication that accompanies technology innovations. Both Dutton (2004) and Rogers (2003) warn of the tendency to view technological innovations as beneficial, rather than to carefully weigh both positive and negative effects of each innovation or cluster of innovations. Critics of IT in education have noted evidence that IT is 'oversold and underused' (e.g. Cuban, 2001; Oppenheimer, 2003). A major criticism focuses on whether computers are as cost-effective as other interventions, such as smaller class size, and the rapid continuing changes of IT have often been ignored in this 'rush' to innovate.

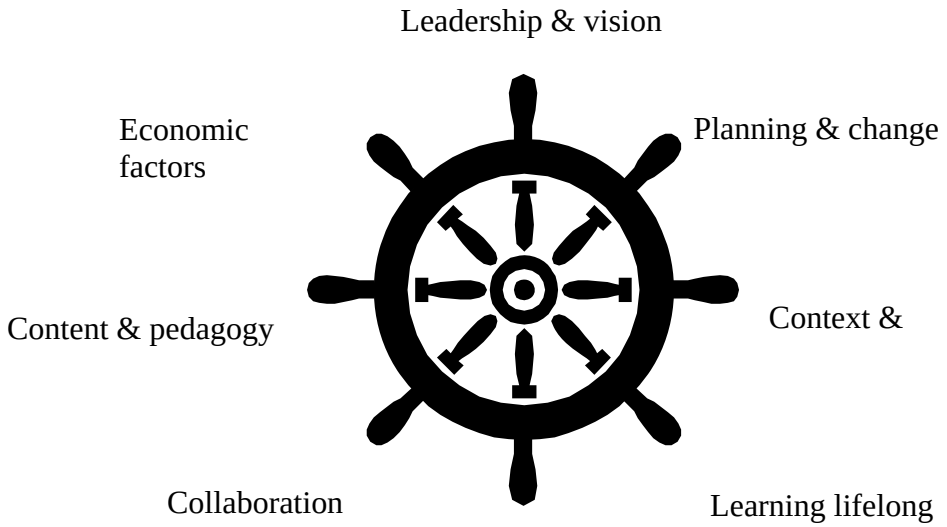
The ecological perspective is useful to review and interpret past initiatives, and to understand where IT adoption was unsuccessful. Nielson (1998) provided an example of a failed e-mail innovation that connected curriculum in two high schools in Canada, which was set up by university faculty as part of a federally funded telecommunications project to study the teachers' innovations with the goal of transforming students' literacy. In 1991 it was a project ahead of its time. The project was frustratingly delayed when a state department of education requested further detail on use of the network to meet their curriculum guidelines. The researcher had not been prepared for this having been "armed with the teachers' enthusiasm and emboldened by the prospect of significant funding from the province". After permission was given to connect the telecommunications provider, technical difficulties in the more rural school, with a locked computer room and uncertainty of the principal became clear (1998: 136). These were followed by the development of some innovative practice. In the twenty-first century, the risks of social technologies are better understood and guides to good practice are published on the web sites of a number of national and international agencies (e.g. ISTE, BECTA). Review of these challenges experienced by this project and the later development of resources, using Figure 1, clarifies why teachers cannot adopt IT independently of their school and community, and the guidance freely available to educators, students and their parents provides evidence of the influence of national and international agencies.

Commercial marketing and politically-motivated promotion of IT innovations also plays a role in technology diffusion in innovation. Slewyn's (2002) system-wide study of changes in IT in education, encompassed national and international organizations to provide evidence of the socio-economic forces that have pushed technology diffusion in the U.K. Selwyn's discursive deconstruction of educational computing in the UK indicates evidence from many sources, including the marketing literature of the government sponsored *BBC computer* and the policies of the government of France, Japan, and the U.S. which influenced the British government. His interviews of government officials and advisors and multinational corporations that sold hardware, software, and telecommunications to schools trace the origin of the U.K. 'National Grid For Learning' as a strategic vision for the nation. Although, according to the executive of

a multinational IT corporation, "the actual adage in the entire IT industry is that education is 'high maintenance/low margin' business" (p 65). Selwyn provides evidence that these companies see multiple benefits from the educational sector: profit, educational branding for sales to the much larger home market, employable people for their IT sector, and building of a future consumer base. These economic motivations may be obscure to educators.

Figure 1 contains a profusion of factors to inform a global perspective, but it is relatively unhelpful to leaders planning change. Therefore, Figure 2 provides a bird's eye view of the critical success factors for educational renewal with IT in the twenty-first century information society (Davis, 2005). The eight interacting components are: leadership and vision; planning and the management of change; context and culture; lifelong learning with a core of teacher education; technical factors; collaboration and networking; content and pedagogy; and finally, economic and human factors. It is critical that leaders in education develop a capacity to steer their organization, the metaphor of a wheel with eight spokes maintaining the balance between these components is useful to emphasize the holistic and interacting nature of these critical success factors. The metaphor also implies that educators, policy makers, and researchers need to learn from one another and not 'reinvent the wheel.' Student learning is at the center of the wheel surrounded by teacher learning for educational renewal. The first version was developed under the author's leadership (Davis & Tearle, 1999) through action research and expert reviews during an international project to integrate communications technologies in preservice teacher training involving seven European countries. This was revised and updated by a team of international experts for the UNESCO (2002) *ICT Teacher Education Planning Guide* and again reviewed by experts, and has been translated into five languages to date. Davis 2005 was a further development of this framework stated by UNESCO's conference to identify critical success factors.

Figure 2. Interactive framework for a holistic view of the critical success factors for IT capacity building (Davis, 2005) (to be better designed before publication)



Technical factors

Note: Center circle represents student learning and the surrounding circle represents teacher learning

In relation to critical success factors in Figure 2, the most obvious factor identified by Selwyn was economic, but deeper probing can identify all eight factors in the interactive framework. Similarly, careful reading of Zhao's systemic research of schools indicates the presence of all eight factors (Zhao & Czico, 2001; Zhao, Pugh, Sheldon & Byers, 2002).

A perspective of a school maturing with IT

Organizations also go through stages in the adoption (and/or rejection) of innovations. Rogers' terminology for the five stages of organizational change is: agenda-setting; matching; redefining/restructuring; clarifying; and routinizing (2003: 420). However, IT is not a benign innovation and, as a result, organizations that adopt one or more IT-related innovations experience further changes stimulated by the adoption of IT. That is Rogers' clarifying and routinizing processes are disrupted by further innovations with IT. A simplified version of this sequence, known as a maturity model, is provided in Figure 3. This sequence starts with localized exploitation by one or more school teachers' adoption of one or more IT innovations and then, as the number of adopters increases and activity proliferates, the increasing demand for resources stimulates management to appoint an IT coordinator to manage demand and coordinate internal integration. The range of innovations continues to expand and also become further embedded into the organization through the work of the IT coordinator and other adopters, who network together to redesign their curriculum and educational practice. The next stage involves IT in a redesign of the school's external networks, which often leads to further embedding of IT with external organizations such as partner schools and educational authorities that require information and provide support. Few schools reach the innovative stage where they redefine their scope, which has been seen in other sectors including commerce, e.g. the banking sector. It is widely recognized that restraints from regional and national authorities, including national standardized tests and higher education institution's entry requirements, act to curtail innovation.

Figure 3. The stages of organizational maturity with IT innovations.

1. Localized: Localized Exploitation
    2. Coordinated: Internal Integration (coordination)
        3. Transformative: Process Redesign (internal)
            4. Embedded: Networking Redesign (external)
                5. Innovative: Scope Redefinition

The 'loosely coupled' nature of educational organizations (Weik, 1976) combined with conflicting pressures of authorities beyond the school (see Figure 1) tend to make this process of organizational change much more chaotic and uncertain. It appears that established schools and colleges often move from localized exploitation to the second stage of internal integration with an IT coordinator, but further 'maturation' to redesign educational processes or external networks is rare. The final section of this paper will review evidence for the exceptional organizations that move to stages 4 and 5, but this section limits its consideration to stages 1 to 3. The first three stages moving from localized exploitation to internal process redesign are common in the twenty-first century (Passey & Rigeway, 1994). Tearle (2003) provides a detailed case study of an exemplary U.K. secondary school that was mature and stable at the stage of internal process redesign, probabaly due to such external factors.

Rogers (2003) recognized that organizations, as well as individuals, may reject innovation after earlier adoption. That is, a school may revert back from its adoption of IT. Early diffusion studies in education found that the best predictor of school innovativeness was educational expenditure student (Rogers, 2003: 61). Hargreaves (2003) provides an illustration of a knowledge-society school, Blue Mountain, which was set up as an exemplary 'learning organization' with state of the art technology used effectively in learning, teaching, and administration, with support from an IT coordinator. This organizational structure, which appears similar to an educational process redesign (stage 3 in Figure 3), was not sustained following external shocks of budget cuts and changes in leadership that are part of the regular cycle of Canadian schools. The Blue Mountain School reverted to a more traditional approach with localized exploitation and internal integration of IT. Contextual factors vary with normal rhythms of personal and organizational lives, such as the school year, as well as being subject to external shocks, such as imposed reforms and weather-related disasters. Hargreaves attributed the reversion of the Blue Mountain School to changes in leadership and reduced resources. Today in the US and the UK, the focus on high stakes assessment has reduced opportunities for IT innovation, because these major assessment activities often push innovation with IT towards the end of the school year followed by a long vacation during which the innovation is likely to be forgotten.

Rogers (2003) discusses additional factors that are involved when collective decisions are made about clusters of innovations. The first to innovate, both individuals and organizations, are unlikely to be perceived as similar by others and so are not to be in a good position to transfer their approaches to more traditional organizations. Hargreaves (2003) observed that, although the Blue Mountain School was held up as a beacon of good practice nationally, it was not successful in transferring practice to schools in its district. The innovative Blue Mountain School has rich social networks, but as an innovative school it was not perceived as similar by the surrounding schools. The international study of innovative schools by Law and her team also recognized that the international case studies of 'innovative schools' (mainly at stages 3 and 4) were collected and analyzed by the SITES2 project that was unlikely to provide a model for schools that adopted IT at a later time (Yuen, Law & Wong, 2003).

A perspective of the teacher innovating with IT

The key individual in education is the teacher. Readers may find it useful to apply the theory and research reviewed in this section to a classroom teacher who is moving through the process of adopting and/or rejecting IT for teaching a specific topic. Rogers (2003) conceptualized steps in an individual's decision making process about whether to adopt or reject an innovation as: knowledge, persuasion, decision, implementation, and confirmation. Rogers also described an individual in terms of their innovativeness using the following adopter categories: innovator, early adopter, early majority, later majority, and laggard. Characteristics have been identified for each category. Early adopters typically have better education and rich social networks when compared with the 'later majority' and especially the laggards who tend to be more socially isolated.

The process of innovation takes time and the stages in adoption and/or rejection can be characterized for the individual and/or the community(s) in which they work. Evidence supporting Hall and Hord's (1987) Concerns Based Adoption Model (CBAM) that centers around Stages of Concern and related Levels of Use emphasizes that IT adoption is more likely to occur when the innovation is perceived as addressing the teacher's personal concerns. Although the concerns of teachers are likely to relate to the technology (hardware and software) they also cluster with concerns relating to their content and pedagogic knowledge, recently known as 'technological pedagogical content knowledge (TCPK)' (Mishra & Kohler, 2007, in press). For example, a teacher who decides to adopt a specific piece of software, such as a word processor, must adapt space and time for hardware, software, and curriculum resources. Becker & Riel (2008, accepted) provide evidence that more effective pedagogy with IT aligns with constructivist approaches. In addition, evidence of student achievement gathered through IT during curriculum activities is likely to require additional teacher learning before value can be added for assessment and accountability purposes (Underwood & Dillon, 2004).

A seminal long-term study of the innovative Apple Classroom of Tomorrow (ACOT) identified five stages of 'instructional evolution' for a teacher using IT in well resourced classrooms accompanied by ongoing professional development. The stages were: entry, adoption, adaptation, appropriation, and invention (Dwyer, 1994; Sandholtz, Ringstaff & Dwyer, 1997). Students of ACOT teachers at this final stage demonstrate high levels of skill with IT, an ability to learn on their own, problem-solving, and movement toward more collaborative work patterns. The CBAM and ACOT stages of teachers' pedagogical innovation with IT have been developed further by Sherry et al (2000) into the 'Learning/adoption trajectory' model with the following stages: teacher as learner, teacher as adopter, teacher as co-adopter, teacher as reaffirmer or rejecter, and teacher as leader. The later stages promote other teachers' adoption, particularly the final stage of 'teacher as leader' who advocates for IT and provides support to others thus increasing the permeation of IT. It is important to note that a teacher's own learning though ICT, online professional development, is unlikely to be successful in the early stages of IT adoption (Davis, Preston & Sahin, in prepration).

Software design and pedagogy are not culturally neutral and they are strongly related to funding, as noted earlier. The lack of equitable access to IT and related socio-technical change forces impact on teachers and their schools differentially. In addition, minority teachers typically have less access to IT in school and at home (Resta, 2008, accepted;

Clark & Gorski, 2001). The same applies within teacher education programs for minority teachers (Bowser Brown, 2005). In addition, access to high speed Internet is more likely to be problematic for teachers and schools in rural areas. Rogers (2003) discussed equity issues in his chapter on 'unexpected consequences'. One strategy adopted to reduce disparity is to start the introduction of IT with a disadvantaged group. For example, the national Enlaces project in Chile that successfully introduced IT into education started the innovation by working with indigenous people who did not have a written language. Thus the first stage was to develop and pilot a graphical interface and a culturally appropriate curriculum (Hinestrosa, 2008, accepted).

In summary, models of change emphasize that the individual teacher's personal context and concerns appear paramount to effective development of IT in education.

Attributes of innovations and essential conditions for adoption

Rogers' (2003) own seminal research identified that "Innovations have attributes that influence the speed of their adoption and/or rejection in particular contexts as follows: relative advantage, compatibility, complexity, trailability, and observability." Evidence that these attributes are also the most importation for innovations with IT in education has been provided by Ferster (2006). After accumulating an extensive list of factors through a literature and expert input, Ferster applied neural network analysis trained with 37 educationally situated innovations and then tested the network with six IT-related innovations. This systematic analysis confirmed that Rogers (2003) had selected the five most influential attributes of innovations that predicted success with over 90% accuracy. It is recommended that developers of IT for education maximize these characteristics, while also interpreting them in the light of the models and research reviewed.

Application of these characteristics involves consideration of the context in which teachers and organizations innovate with IT. Donald Ely (1990) provided evidence of eight conditions that facilitate IT innovation: dissatisfaction with the status quo, knowledge that skills exist, commitment by those involved, resources are available, time is available, participation is expected and encouraged, and leadership is evident. ISTE has promoted these as 'essential conditions.' "Dissatisfaction with the status quo" is a common motivation that stimulates pedagogic innovation when matched with an IT application that is perceived to address the individual's dissatisfaction, which could also be viewed as a teacher's concern and/or as an organizational benefit. Ely (1990) extended his research into contexts that were foreign to the original developers (technically, linguistically, and culturally) and found that all these conditions continued to be relevant. Leaders manipulate these conditions to promote adoption of IT. Thus further evidence for these conditions arises from research on leadership strategies (Yee, 2001; Lewis, Jenson, and Smith, 2003).

Simultaneous Renewal of Preservice teacher education and K-12 schools

In order to better understand the complexity of change introduced in Figure 1, we now turn to the preparation of future teachers. Common approaches to technology in

preservice teacher education programs are: a stand alone technology course and the infusion of technology into methods, foundation, and field experience courses (Davis & Schmidt, 2007). Best practice uses a combination of these and applies technology to enhance teacher education while also modeling practice for K-12 schools leveraging technology, pedagogy and content knowledge synergistically (Davis, 2003; Mishra & Kohler, 2007, in press). Teacher education institutions also appear to progress through similar maturation stages with IT, but change is more complex because IT in learning and teaching must also involve partnering K-12 schools where students practice teaching. Goodlad (1994) called this simultaneous renewal of teacher education and K-12 education.

Studies of organizational change with IT in preservice teacher education provide evidence of organizational change similar to that discussed earlier for K-12 schools and colleges. The first national project to integrate IT in preservice teacher education, Project INTENT in England, provides insight into the change process in five different organizational structures and the micro politics of institutional change, which moved all five institutions one stage in organizational maturation from IT from the localized stage to coordinated integration of IT with potential for internal process redesign (see Table 3) (Somekh & Davis, 1997). Somekh, Whitty and Coveny (1997) derived key concepts and strategies empirically and then compared and contrasted them with well known theories of innovation at that time. They confirm Fullan's view that change is a messy mixture of problems, excitement, and the power of individuals to bring about change (1991: 345). I provided provided detail of strategies that evolved in a college of teacher education with a description of the complementary institutional (macro) and individual (micro) strategies that were adopted for staff development that involved all stake holders on the campus during project INTENT (Davis, 1997).

It is very challenging to provide evidence to link changes in preservice teacher education to outcomes in K-12 schools and it requires tight alignment of conditions in preservice teacher education program and partnering K-12 schools. A rare example is Garofalo's (2006) modeling of the use of an interactive whiteboard for preservice math teacher education students who then adopted this technology during clinical practice in K-12 school classrooms with the same interactive whiteboard, resulting in evidence of positive impact on K-12 students' achievements. It appears that sharing of IT-related content taught using a model approach that tightly scaffolded beginning teachers' TCPK, so that they were able to reapply their own learning experience with IT into the K-12 context (equipped with the same IT resources), and these together appeared to impact student learning more than the teaching of accomplished high school math teachers.

Change models can be used to inform this complex 'simultaneous renewal.' Thompson, Schmidt & Davis (2003) describe their innovative project that undertook simultaneous renewal of a university teacher education program and four elementary schools. The authors successfully used a simplified version of Havelock and Zlotow's (1995) stages of planned change as a framework for a structured interview, see Figure 4. Both project leaders were able to identify elements within all of the CREATER stages (Care, Relate, Examine, Acquire, Try, Extend, Renew) and generate more strategies for the later stages

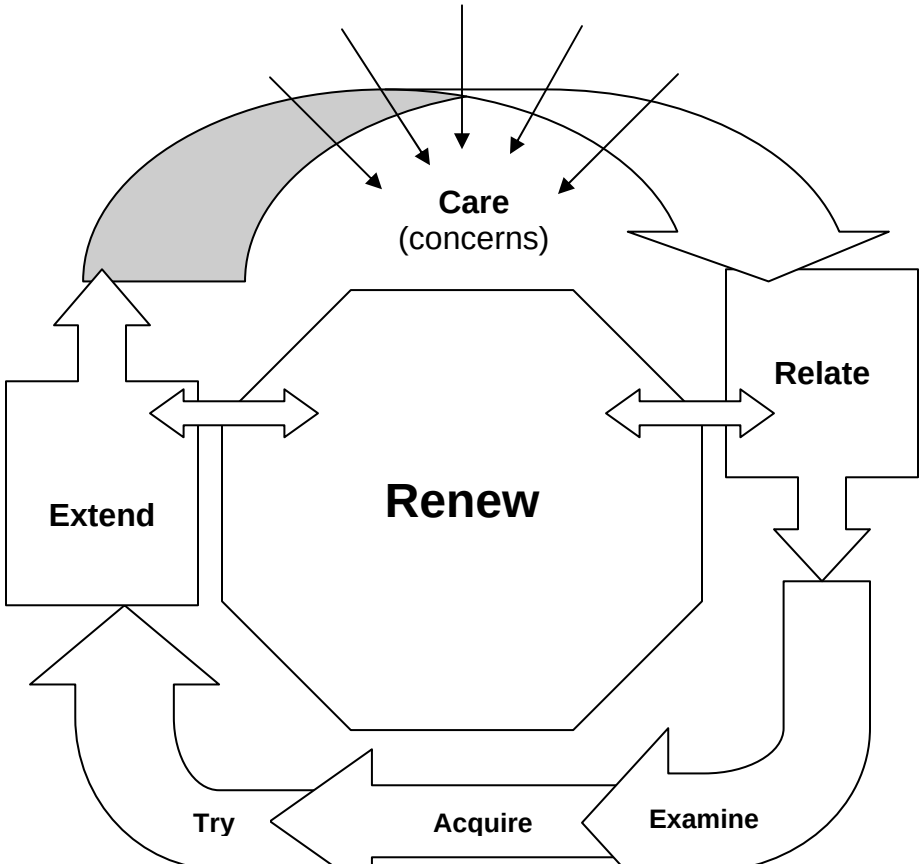
of Extend and Relate that are often ignored in innovative projects. They also recognized that a second cycle was underway to address concerns that arose as a result of the first cycle planned for further cycles.

It is useful to note that teacher education requires simultaneous renewal across a number of organizations and thus IT innovation in teacher education stimulates further change. All the individuals and organizations involved move through stages of adoption and maturing use of IT in a messy multilevel process that may be facilitated or retarded by multiple leaders and change agents.

Revolutionary change with Virtual Schooling

IT may also be causing revolutionary change in educational organizations accompanied by changes in educators' roles and responsibilities. Natriello (2005) noted that new organizations such as Open Universities and Virtual Schools on several continents have reconfigured their processes to take better advantage of IT. IT has enabled the development of Virtual Schools and Virtual Universities and their interactions with traditional schools are likely to be destabilizing due to demands of students, their parents, the state, and the nation. For example, Florida as a state has mandated that distance learning courses from Florida Virtual Schools are an option for all students in K-12 schools and the U.K. Open University both competes and collaborates with many U.K. universities and has supported the creation of similar universities on other continents. These organizations, with embedded and innovative IT, commenced their operations in one of the two final revolutionary stages of organizational maturation (see Figure 3).

Figure 4. The CREATER model of the process of change (Thompson, Schmidt & Davis, 2003; adapted from Havelock and Zlotolow, 1995)



Part of the reconfiguration of these virtual schools unbundled the teaching role. The author's research on the roles and responsibilities of educators involved in K-12 distance learning confirms this unbundling. The teacher's role has been unbundled into at least three roles: virtual classroom teacher, K-12 student facilitator, and instructional designer (Harms et al, 2006). The underlying innovation process for a teacher in a Virtual School with internet-based teaching also contrasts strongly with the approach a teacher in a traditional school adopting videoconference (Davis & Niederhauser, 2005).

The third world has also adopted and adapted IT for distance education in their contexts. Additional concerns of teachers and leaders in these contexts arise from lost generations of teachers due to AIDs, war and other disasters, and the lack of existing IT infrastructure and skills. Innovative approaches include radio, IT centers, and the use of handheld IT (Leach et al, 2004). Networks for IT education and teacher education that are being developed in sub Saharan countries in partnership with multinational IT companies, including Cisco and Microsoft (Selinger, 2006). Applying Selwyn's (2002) analysis of diverse goals of partners supporting IT innovation in education, that was discussed earlier, suggests that it remains important for leaders in all contexts to retain a clear educational vision steered by all the critical success factors in Figure 2, so as to retain an appropriate balance. Educational innovation with IT also serves an IT company's need for skilled workers to in order to provide an IT infrastructure for their services. Dutton (2004) warns of this double edged nature of IT.

Summary and conclusions

This paper has provided systems perspectives with related research to inform educational renewal. The theory started with global and holistic models followed by progressively closer perspectives in educational systems, ending with the most detailed perspectives of the individual teacher, the IT innovation and its context. Evidence to support these theories was accompanied by illustrations of strategies and initiatives. Simultaneous renewal with IT preservice teacher education and K-12 schools provided further evidence for these theories. The final section reviewed research into the emergence of radically different educational organizations, virtual universities and schools, accompanied by radical shifts in processes mediated by IT and the unbundling of the teacher's role and responsibilities into a number of roles in a variety of locations linked by IT. This synthesis has drawn upon the seminal interdisciplinary work on the diffusion of innovations led by Everett Rogers (2003) confirming that his axioms also apply to IT in education. This paper also indicates that many studies of IT in education have taken too

simple of an approach and that much research remains to be done that recognizes the ecology in which IT is embedded so that it has a better chance to act as an agent of change.

Acknowledgements

I would like to acknowledge Iowa State University and the University of Otago for support during my sabbatical when I prepared this paper, a related course and book proposal. A version of this paper has been accepted as Davis, N.E. (2008, accepted).

References

Becker, H. & Riel, M. (2008, accepted) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.

BECTA web site http://www.becta.org.uk

Bowser-Brown, A. (2004). A Critical Look at the Disparities of the Digital Divide for Minority Preservice Teachers. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2004* (pp. 4035-4038). Chesapeake, VA: AACE.

Bradley, R. (1992) *IT Handbook for Teachers*. Hemel Hempstead: Simon & Schuster Education.

Christianson, R. & Knezek, G. (2008, accepted) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.

Clark, C., & Gorski, P. (2001). Multicultural education and the digital divide: Focus on race, language, socioeconomic class, sex and disability. *Multicultural Perspectives*, 3(3), 39-44.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom.* Cambridge, MA: Harvard University Press.

Davis N.E. (1997) Strategies for staff and institutional development for IT in education: an integrated approach. In Somekh B. and Davis NE (Eds.) *Using IT effectively in teaching and learning: studies in pre-service and in-service teacher education.* Routledge: London.

Davis N.E (2002) Leadership of information technology for teacher education: a discussion of complex systems with dynamic models to inform shared leadership. *Journal of Information Technology for Teacher Education*, 11, 253-271.

Davis N.E. (2003). Technology and teacher education in the USA: What makes for good sustainable practice? *Technology, Pedagogy and Learning*, 12(1), 59-84.

Davis, N.E. (2005). *Critical success factors for ICT building capacity in information societies: Outcomes from UNESCO's world conference.* IFIP WG 3.3 and 3.6 web sites.

Davis, N.E. (2007, accepted). Global interdisciplinary research into the diffusion of technology innovations in education. Paper to be presented at AERA Conference, Chicago, April, 2007.

Davis, N.E. (2008, accepted). How many teacher learning be promoted for educational renewal with IT? Models and theories of IT diffusion. In Joke Voogt &

Gerald Knezek (Eds.), *International handbook of information technology in education.* Amsterdam: Kluwer Press.
Davis, N.E., & Niederhauser, D.S. (2005). Socio-cultural analysis of two cases of distance learning in secondary education. *Education and Information Technologies*, 10(3), 249-262.
Davis, N.E., Preston, C. & Sahin, I. (in preparation). A national study of ICT continuing professional development: Multi-level evaluation and the characteristics of effective CPD models. *British Journal of Educational Technology.*
Davis, N.E., & Schmidt, D. (2008, in preparation). Technology in preservice teacher education, in ** (Ed). *International Encyclopedia of Education.*
Davis N.E. and Tearle P.A. (1999). The research and development of and international core curriculum for information and communications technology in teacher training. In Willis J. et al., *Annual of the Society of IT in Teacher Education 1999.* Volume 1.
Davis N E, and Thompson, A. (2005). The Evaluation of Technology-Related Professional Development, Symposium and paper. In Crawford, C., Carlsen, R., Gibson, I., McFerrin, K., Price, J., Weber R. & Willis, D.A. (Eds.) *Society for Information Technology & Teacher Education International Conference Annual.* Phoenix, Arizona,USA, March 2005, Association for the Advancement of Computing in Education: Charlottesville, VA.
Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. *Educational Leadership*, 51, 4-10.
Dutton, W. (2004). *Social transformation in an information society: Rethinking access to you and the world.* Paris: Paris: UNESCO WSIS Publication Series; and http://portal.unesco.org/ci/en/ev.php-URL_ID=12848&URL_DO=DO_TOPIC&URL_SECTION=201.html
Ely, D. (1990). The diffusion and implementation of educational technology in developing nations: Cross-cultural comparisons of Indonesia, Chile and Peru. *Instructional Developments*, 1(1), 9-12 (EJ 331 469)
Ferster, W. (2006). *Towards a predictive model of the diffusion of technology into the K-12 classroom*. Charlottesville, VA: Unpublished dissertation, University of Virginia.
Fullan, M. (2001). *The new meaning of educational change*. Third Edition. New York & London: Teachers College Press.
Garafelo, J. (2006). *Preparing Mathematics Teachers to Use Whole-class Visualization* (Presentation at the Annual Meeting of the Society for Information Technology and Teacher Education, Orlando).
Goodlad, J. (1994). Educational Renewal: Better Teachers, Better Schools. San Francisco, CA: Jossey-Bass.
Hall, G. & Hord, S. (1987). *Change in Schools: Facilitating the Process.* Albany, NY: State University of New York Press.
Holloway, R. (1996). Diffusion and adoption of educational technology: a critique of research design. In D. Jonassen (Ed.) *Handbook of research for educational communications and technology.* (pp. 1107-1133) New York: Simon & Schuster Macmillan.

Giles, Corrie & Hargreaves, Andrew (2003). The Sustainability of Innovative Schools as Learning Organizations and Professional Learning Communities During Standardized Reform. Educational Administration Quarterly, Vol. 42, No. 1, 124-156 (2006)

Harms, C.M., Niederhauser, D.S., Davis, N.E., Roblyer, M.D., Gilbert, S.B. (2007). Educating educators for virtual schooling: communicating roles and responsibilities. *Electronic Journal of Communication.*

Havelock, R. & Zlotolow, S. (1995). *The Change Agent's Guide* (2nd ed.). Educational Technology Publications, Englewood Cliffs, NJ.

Hinestrosa, E. (2008, accepted) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.

ISTE web site http://www.iste.org

Kirkman, C. (2000). A model for effective management of information and communication technology development in schools derived form six case studies, *Journal of Information Technology for Teacher Education*, 9(1), 37-52.

Lai, Kwok-Wing (2001). *e-Learning. Teaching and professional development with the Internet*. University of Otago Press.

Leach J, Patel Rakhee, Peters Alexis, Power Thomas, Ahmed Atef, & Makalima Shumi (2004). Deep impact: a study of the use of hand-held computers for teacher professional development in primary schools in the Global South1. *European Journal of Teacher Education*, 27(1), 5-28.

Law, N. (2008, in preparation) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.

Jenson, J., Lewis, B., & Smith, R. (2002). No One Way: Working Models for Teachers' Professional Development. *Journal of Technology and Teacher Education 10*(4), 481-496. [Online]. Available: http://dl.aace.org/10617

Mishra M.J., & Kohler, P. (2007, in press). *Handbook of technological pedagogical content knowledge.* A new framework for teacher knowledge. Washington, DC: American Association of Colleges of Teacher Education.

Natriello, G. (2005). Modest Changes, Revolutionary Possibilities: Distance Learning and the Future of Education. *Teachers College Record*, 107 (8), 1885–1904.

Nielson L. (1998). Coding the light: Rethinking generational authority in a rural high school telecommunications project. In Reinking, D., et al *Handbook of literacy and technology. Transformations in a post-typographical world.* Mahwah, NJ: Laurence Erlbaum Associates.

Oppenheimer, T. (2003). *The flickering min: The false promise of technology in the classroom and how learning can be saved.* New York: Random House.

Owen, Gavin (1992). Whole School Management of Information Technology. *School Organisation*, 12, 29-40.

Passey, D. & Ridgway, J. (1994) The Current Impact of IT, and the Stages of School IT Development: are there any prospects for the future? *Computer Education*, 76, pp. 2–5.

Preston, C. (2004). Building communities of practice in 'New' Europe. In Brown A. & Davis N.E. (Eds.) *Digital technology, communities and education. World Yearbook in Education 2004.* London: Routledge

Preston, C., Mannova, B, & Lengel, L. (2000). Collaboration though technology now and in the future: Linking the New Europe with the World. In L. Lengel (Ed). *Culture @ technology in the New Europe*. Stamford, CN: Ablex.
Resta, P. (2008, accepted) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.
Rogers, Everett (2003). *The diffusion of innovations*. 5th Edition. New York: The Free Press.
Sandholtz, J. H., Rignstaff, C. and Dwyer D. C. (1997). *Teaching with Technology: Creating Student-Centered Classrooms. New* York: Teachers College Press.
Selinger, M. (2006). I teach you, you teach me. Keynote paper for SITE conference, Orlando, March.
Selwyn, N. (2002). *Telling tales on technology. Qualitative studies of technology and education.* Burlington, VT: Ashgate.
Senge, P. (1990). *The fifth discipline.* New York: Doubleday.
Sherry, L. (2002). Sustainability of innovations. *Journal of Interactive Learning Research*, 13(3), 211-238.
Sherry, L., Billig, S, Tavlin, F. & Gibson, D. (2000, February). New insights on technology adoption in schools. *T.H.E. Journal*, 27(7), 43-46.
Sherry, L. & Gibson, D. (2002). The path to teacher leadership in educational technology. *Current Issues in Technology and Teacher Education*, 2(2).
Somekh, B. (2008, accepted) In Joke Voogt & Gerald Knezek (Eds.) *International handbook of information technology in education.* Amsterdam: Kluwer Press.
Somekh B. and Davis N.E. (Eds.) *Using IT effectively in teaching and learning: studies in pre-service and in-service teacher education.* Routledge: London.
Somekh, B, Whitty, G & Covney, R. (1997). IT and the politics of institutional change. In Somekh B. and Davis NE (Eds.) *Using IT effectively in teaching and learning: studies in pre-service and in-service teacher education.* Routledge: London.
Strudler, Neal (1995-96). The role of school-based technology coordinators as change agents in elementary school programs: A follow-up study. *Journal of Research on Computing in Education*, 28(2), 234-257.
Strudler, N, & Gall, M.D. (1988, April). Overcoming impediments to microcomputer implementation in the classroom. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. (ERIC ED 298 938)
Surry, D.W. & Farquhar John D. (1997, February). Diffusion theory and instructional technology. *Journal of Instructional Science and Technology*, 2(1). [online] http://www.usq.edu.au/electpub/e-jist/docs/old/vol2no1/article2.htm
Tearle, P. (2003). ICT implementation: what makes the difference? *British Journal of Educational Technology*, 34(5), 567-583.
Telem, M. (1996). MIS implementation in schools: a systems socio-technical framework. *Computers Education*, 27(2), 85-93.
Thompson, A. D., Schmidt, D. A., & Davis, N. E. (2003, January) Technology collaboratives for simultaneous renewal in teacher education. *Educational Technology Research and Development*, 51(1), 71-87.
Tong, K.P. & Trinidad, S.P. (2005). Conditions and Constraints of Sustainable Innovative Pedagogical Practices Using Technology. *International Electronic Journal for Leadership in Learning*, 9(3). Available: http://www.ucalgary.ca/~ijell/

Underwood, J. & Dillon, G. (2004). Capturing complexity through maturity modeling, *Technology, Pedagogy and Education,* 13(2), 213-225.
UNESCO (2002) *ICT in teacher education. A planning guide.* UNESCO: Paris, France. http://unesdoc.unesco.org/images/0012/001295/129533e.pdf Also in the Handbook online appendices.
Weik, K.E. (1976) Educational organizations as loosely coupled systems. *Administrative Science Quarterly*, 21, 1-19.
Yee, D. (2000). Images of school principals' information and communications technology leadership. *Journal of Information Technology for Teacher Education,* 9(3), 287-302.
Yee, D. (2001). The many faces of ICT leadership. In B. Barrell (Ed.), Technology, teaching and learning: Issues in the integration of technology (pp. 223-238). Calgary, AB: Detselig.
Yuen, A.H.K., Law, N. & Wong, K.C. (2003). ICT implementation and school leadership: Case studies of ICT integariton in teaching and learning. *Journal of Educational Administration*, 41(2), 158-170.
Zhao, Y. & Czico, G.A. (2001). Teacher adoption of technology: A perceptual control theory perspective. *Journal of Technology and Teacher Education*, 9(1), 5-30.
Zhao, Y, & Frank, K.A. (2003). Factors affecting technology uses in schools: an ecological perspective. *American Educational Research Journal,* 40 (4), 807-840.
Zhao, Y., Pugh, K, Sheldon, S., & Byers, J. (2002). Conditions for classroom technology innovations. *Teachers College Record,* 104(3), 482-515.

Paper 3

Collaborative Knowledge Construction in Developing ICT Tools for Education

Andrea Kárpáti and Kornél Varga
Eötvös Loránd University, Faculty of Sciences,
UNESCO Chair for ICT In Education, Budapest, Hungary

Abstract. The paper provides an overview of the elaboration, testing and improvement of Movelex, a complex virtual learning environment (VLE) supporting the establishment of self-regulated learning and shared knowledge building space. The development and continuous improvement of the software has the aim to form *communities of practice* of teachers and students to co-operate with software programmers in the creation of new functionalities and widening of the array of pedagogical options. Therefore, the VLE called Movelex is not just a product; it is tool and a Web-based digital learning content development platform at the same time – and in both capacities, extremely user-friendly and supports building a community of practice for technology-enhanced learning. The paper refers to the *Knowledge Practice Laboratory Project* (KP-Lab), to elaborate new models for in-service teacher training aimed at assisting future teachers in the *co-evolution process* of technical and pedagogical skills development through a VLE enhancement exercise.

Key words: Self-regulated learning, collaborative learning, Web-based, VLE, communities of practice, Movelex

1. Theoretical Foundations

Virtual Learning Environments have decades of developmental history. Still, they fail to yield educational results promised by their developers – an impressive improvement in the quality of teaching and learning that would justify investment in their development. Teachers, irrespective of the quality and quantity of infrastructure and training courses offered, are still reluctant to use them [1]. According to case studies in 21 OECD countries ranging from school cultures of Mexico to Finland, those who make optimal use of ICT technology are innovative teachers who have been equally successful in "non-digital" educational innovation [2].

Teachers complained that learning management systems (LMS) may have a search functions may convey pedagogical message, but the whole environment represents an "HTML logic" – it does not alter the logic of a book. (Many LMS systems actually contain digital versions of textbooks.) Learning Object Repositories offer independent units that may be interrelated in numerous ways, but teachers find it difficult to match them with curricular content and requirements. Collaborative learning environments (CSILE), for example Knowledge Forum involves co-construction of knowledge – however, text and images are imported into the system from outside sources and require considerable investment in time and effort. These tools may also be quite difficult to handle for teachers who soon develop anxiety and avoid the whole ICT culture [3]. Movelex was developed to offer a solution for Hungarian teachers trained in basic ICT literacy but reluctant to use pre-packaged digital material. Movelex invites teachers to act as co-developers: customize and expand an easy-to-use, flexible, still well-structured learning environment. This feature is considered especially beneficial for matching curricula and VLE-s [4].

This VLE focuses on two main pedagogical goals:

- To support *individualized instruction,* self-regulated and cooperative learning;
- To help teacher communities produce and share learning materials through the Web in a pedagogically structured environment adapted to curriculum requirements

In order to realise these objectives, educational methodology, information technology and the organisation of the use of the system have to be considered in synergy. Movelex differs from most other VLE-s in the following key features:

- Movelex reflects teachers' teaching methods – may be used flexibly for various teaching and learning styles;
- It does not require technological skills – even basic knowledge about this software results in functional learning solutions that teachers can use at once at school;
- The conceptual framework of the curriculum may be directly translated into a set of Movelex learning objects and their relations.

A key problem of self-regulated learning is that students have difficulties in identifying their own learning problems and state that it is the "whole" material that they cannot grasp [5], [6]. Lacking easily applicable diagnostic tools, teachers cannot help localising the knowledge deficit or skill development gap because the ruling paradigm in Hungary, frontal education leaves no room for motivation or detection of individual handicaps. Frontal teaching results in a loss of control over individual learning processes by the teacher while learners also loose motivation.
These findings indicate that many teachers fail to understand interrelationships, although research on *conceptual maps* or Bruner's theory on the importance of "*structure*" both emphasize "interrelationships" as a key design aspect that provides usable knowledge [8]. Even knowledge transfer depends on the ability of the learner to acquire structures and identify special occurrences of a general phenomenon [9]. Our conclusion is therefore that a real educational software solution cannot neglect handling references and structures. Thus, the challenge for educational software specialists is to provide a *dynamic learning platform* with a wide range of learning paths and content options that, at the same time, provides well-designed learning steps and adequate scaffolding for the learner and constant supervision for the teacher.
It is generally accepted that ICT may play a beneficial role in the realisation of contemporary educational paradigms. However, *learning objects (LO-s),* core elements of e-learning material design aim to promote reusability and variability by not containing references to other LO-s. Even these basic units, however, contain a set of concepts that are not explained or may need further clarification. Even if we omit any hints on previous knowledge, it is still there, inherent in the text and / or image of the LO.
Computer technology could offer a *model for learning as intelligent information processing.* The real solution should integrate texts and visualization with database-like internal structures and thus reduce cognitive load [10]. This is the major technological novelty of Movelex, detailed description of this however doesn't fit into this paper.

2. A Trialogical Model for the Development of Learning Materials

Traditionally, teachers "commission" (express a need for) a digital tool or teaching aid and at best, adapt the finished product – if it is customisable at all [4]. Software developers receive a – transcribed by educational policy makers of marketing specialists – description of the functionalities the product is

required to have. Learners are also not entitled to take part in the developmental process – all they can do is to select features and content that seems to suit their learning styles, previous knowledge and interest best. The problem is lack of a common frame of reference. Teachers and learners cannot reflect on a VLE in a meaningful way if they have not seen such before. However, if a prototype is prepared for piloting, a large amount of work has to be invested before the product is testable – and understandable – for future users. Making changes is slow and requires vast financial and human investment [11].

The traditional method of educational software development is based on *parallel monologues* – those of the teacher and learner, expressing their need for a digital learning tool, and those of the software developer and producer, expressing their special viewpoints and interests. Learning materials developed as a result can only be used for traditional, authoritative "*learning dialogues*" [12].

The EU-funded Knowledge Practice Laboratory defines an innovative model for the co-construction of knowledge that educational software development also has to consider: *trialogical learning.* "Those forms of learning where learners are collaboratively developing, transforming, or creating shared objects of activity (such as conceptual artefacts, practices, products) in a systematic fashion. Trialogical learning concentrates on the interaction through these common objects (or artefacts) of activity, not just between people ("dialogical approach"), or within one's mind ("monological" approach)." (from www.kp-lab.org, the official Website of KP-Lab: KP-Lab Wiki / Trialogical Glossary) Consequently, the realisation of this learning model needs *communities of practice*. On the one hand, it involves learning in self-regulated student groups ("knowledge building communities"), on the other hand, teachers' communities that co-develop learning content to support and guide self-regulated student learning also have to be formed [13].

2.1. Movelex: a New Type of VLE

In order to realise the trialogical learning model, a new type of VLE is needed that enables teachers and learners to interact with learning content directly, through an easy-to-use and flexible environment and thus act as developers themselves. In an ongoing effort, the teacher and learner community develops *both a VLE and new content to be used within this VLE*. Movelex is more than handy software – it is the catalyst of a new teaching methodology thanks to its structure to be explained below. It is based on the active partnership of the teacher (and, at times, the learner) as a provider of content, and the developer as a provider of technical framework for the formulation of content types (texts, images, assessments, animations, sound bites etc.)

This co-evolutionary process has involved hundreds of teachers who take part in the testing educational functionalities of the software environment and learning materials produced within this environment as well. Trialogical development means here to harmonise the didactic needs, background knowledge and school culture of *educators* (teaching professionals), *software engineers* (ICT development professionals) and *learners* with a deep understanding of their own motivation and interest. These groups do not normally work together on a learning material design task as their roles never overlap.

The Movelex Virtual Learning Environment was constructed on the principles described in this paper and have already six years of practical experience. (Its name generates from the English words "moving" and "lexicon".) Below we will describe the basic components of the system:

- *Digital lexicon:* a knowledge repository that makes the implicit structure of the learning content, in the mind of the teacher, explicit. Several innovative features enrich this digital lexicon:
  - Items are not represented as text, but are marked as definitions, remarks, examples and symbols. Teachers may attach categories like age group, school type, target population etc. and the system will filter the items according to the preferences of the teacher.
  - It is also possible to write different interpretations representing levels of difficulty or professional viewpoints for the same concept.
  - *We can differentiate between new and* (supposedly) *known concepts*. This way we can construct a network of concepts that mutually rely on each other. Thus, necessary preliminary knowledge for a certain unit may be defined and the logical hierarchy of learning items may be clearly identified. Therefore, we can avoid the inclusion of non-defined, new concepts on the network.
  - In the lexicon, links not only denote one lexical item, but always refer to the meaning of a word that is needed for the given learning unit. In the lexicon, *every meaning is listed* – with the respective illustration.
  - Among the concepts in the lexicon, *several types of relationships* may be indicated. Apart from subordination (like furniture – table) you can specify synonyms, antonyms, or such intricate sets of relationships like the table of Chemical Elements, a chain of historic events or the origin of species. The material can be arranged according to different structures, for example, make a list of historic events happening in the same period in different parts of the world. (In a printed book, these would be found in different chapters.)
  - The links themselves may also wear tags that associate them with different relationships, therefore even plain text may reflect different relationships. Links are symmetric, which means that their source may also be searched for.
- *Test bank:* several item types make practising and testing more enjoyable (e.g. matching tasks, selection of the right answer, special linguistic and mathematical tasks, inserted images and other multimedia elements). Tasks and tests may contain references to the lexicon, thus facilitating the learner's work with items to be practiced.
- *Image and graph bank:* there is an inbuilt animation software available to produce animated images that may be used both in the lexicon and the test bank.
- *Virtual Communication Environment:* provides a platform for learners' and teachers' dialogues and for the integration of materials developed by users (teachers and learners alike).

In the Movelex VLE exercises (test or practice items) are produced in a word processor, may be corrected at any time, and will be formatted automatically by the VLE. All the user has to do is to save his / her product as a web page and open it with the Movelex Presenter program which can be downloaded from this web-page: www.perfectstudy.org .

A typical Movelex unit consists of the new content as front page material and the lexicon as well as the tasks and exercises are "linked" to its parts. The lexicon helps interpret the concepts of the new learning content, while the tasks and exercises facilitate its elaboration. Practice items offer immediate feedback. Thus, they may be used as formative tests and facilitate knowledge acquisition through repeated testing opportunities with items provided in a random order.
New learning content, tasks and exercises may be combined in a different fashion: a new knowledge area or theme might be introduced by simulations and problem solving tasks (to be solved in small groups). After these, the learner may go to the new content pages to overview and structure his / her newly gained knowledge [14].

2.2 Integrating Text and Visualization

Visualization, the central idea of this VLE, leads to easier and more profound understanding. If the teacher intends to use a simple illustration, it is enough to mention the file name of the image in the text description of the learning material. However, if we want to connect the text with the images (for example, we intend to insert an inscription on the picture or caption it), then we have to use the Movelex *animator (drawing)* component. This functionality is also suited to the level of the user.

Captioning an image can be learnt in minutes. The simplest form is to insert words on an image, sometimes through arrows pointing at different parts of the image. An image thus captioned, may also be used as a test item with students having to connect concepts and pictures through arrows. More sophisticated drawings can also be applied on images: for example, the borders of a country may be paired with its name. This requires a little more practice. To create an animation needs more advanced skills, but even this function can be mastered within a few hours. The animation technique is very simple but amazingly effective at the same time. A photograph may be animated as easily as you move a Barbie doll. Children may use their favourite images to make an animation based on a thematic unit, and thus approach a set of scientific problems with more motivation (the downloadable sample task sequence also contains such animations).

Even the advanced level of the animator function may be used by a 12-year-old computer fan, and enables young users to realise a set of interesting visual tricks. The optimal use of this function is through pair or group work, where different skills and knowledge backgrounds may create a synergy.

The aim of the advanced-level *editing programme* is to integrate LO-s and images, animations etc. in a unified learning system. The content integrated in the Movelex VLE is a specially structured knowledge repository that has substantial additional functions. To produce such a repository file you generally need a special editing solution the educational relevance and organisational requirements of which we briefly describe here. Learning content may be structured in a List of Contents page, similar to the File Manager of Windows. This list may be organised into different rank orders and sub-groups (and thus be used differently in different classes.) The program is able to list, based on links in the tasks and among the items of the lexicon, those concepts that are misinterpreted or not known by learners. At the end of the test, the software gives an advice to the learner on previous knowledge he / she has to repeat. Thus, Movelex performs a *developmental evaluation* function and can be used as a formative test. Images may easily be turned into test items, because illustrations are linked to concepts of the lexicon.

2.3 Simplicity as a Key Factor of Feasibility

On the basic level of the Movelex VLE adding new tests or practice items does not require more than word processing skills, only discipline based educational knowledge is necessary. On the advanced level, if a teacher intends to integrate his new test with other learning materials he / she developed or identified in the Movelex learning content repository, more advanced user skills are needed, but even this can be acquired in the course of a two-day training sessions. This training, however, includes more professional (educational) activities than software skills development. Members of a new learning material development group have to analyze the teaching content they intend to transform into digital content in order to create a coherent semantic web of concepts and facts that cover the whole area to be taught and / or tested in the VLE. Software developers are offered the role of technical advisors and invited sometimes to solve special technical problems. Besides they refine the framework according to the needs of pedagogical experts.

3. Results and experiences

The first development of learning material (databanks for seven disciplines) for Movelex VLE was launched in 2001. By now, its digital content repository contains about 8000 tasks, based in a lexicon of 7000 items. About 300 teachers have been trained, and 100 of them take an active part in the development of the Movelex repository and tools. *One third of those teachers trained became developers and have been involved in this community of practice ever since.* This community building capacity is considered especially important for improving teachers' educational strategies [15].

In-service teacher training courses organised in small village schools with modest infrastructure and unskilled in computer use teaching staff proved that Movelex is user friendly enough to be employed by students and teachers alike [16]. The *inclusion of learners* in the process of digital content development in this project also serves the purposes of talent development.

As a result of assessment of teachers' ICT skills, however, we had to realize, that even a relatively simple software technology might become a barrier for the majority of the participants. This lead to the development of a simplified technology, described before, one that needs only the use of a word processor as. The courses are based on two levels of Movelex facilities: Beginner and Advanced.

Four courses were held in September-November 2006, three in Romania, and one in Budapest for altogether 84 teachers from 41 schools. The first course in Cluj (Romania) was open for native Hungarian teachers living in Romania and Romanian teachers as well. Translation made progress a bit slower, but on the other hand, it gave opportunity for the observation of intercultural aspects.

The second course in Cluj was organized already in separate groups for Hungarian speaking and Romanian speaking teachers. Many of them attended our previous course, but there were new participants as well which made the organization a bit difficult. In addition the participating teachers work with very different ages of students, some of them are teaching in multigrade classes.

Most of the participants had less skills in ICT as would have been necessary. This paper has not the goal to analyze the participants, just to shows that they represent a broad scale in cultural-linguistic background, disciplines taught and ICT competence. This diversity of participants resembled the general classroom situation these teachers are confronted with in their own schools. During training, they experienced similar need for individual instruction that their students are likely to come up with. Thus, training course participants did not only learn about the use of a web-based teaching resource, but also acquired responsive pedagogical methods of individualized instruction.

The course evaluation questionnaires proved, that the participants were satisfied with the training, and most of them wants to collaborate and become member of this web-based learning tool developmet community. The VLE itself and the teaching technology used helps participants to overcome technical barriers and develop their own learning materials. At the beginning they individually worked through an e-learning material which summarized the basic technical skills needed for successful completion of the course. There are easily understandable explanations, animations, drills and test in the course units to teach about basics (e. g. how the library system of Windows works, how to create a table in

Word, what is an html format or how to handle pictures). This tutoring material was developed by the Movelex system itself, so it is a good introduction to the VLE's potentials.

This way we ensured that after overcoming the first technical obstacles, participants could focus on the content of learning materials. Teachers observed during training seem to go through a similar route:

1. At the beginning of the first course, they ***cannot even imagine*** that they will be able to produce, within a few hours, really usable e-learning materials for teaching and assessment.
2. After having some experience with their first home-made materials ***they produce textbook-like materials***, with some links and illustrating pictures or animations. Assessment items written by them require merely memorized facts.
3. After several months they start to realize, that the real question is to ***become aware of their tacit knowledge*** and make the connections of the concept map and the different possible viewpoints of their subject explicit. At the same time tests tend to focus more on the abilities of students.
4. As next step they have to realize and put into practice the theory of ***boundary crossings*** and construct connections among different subjects.
5. A different, but similarly problematic process is to bring them to ***handle a CSCL in the classroom***.

When reaching the 2nd stage, teachers start inquiring about the advanced possibilities of the next technological level. This level needs already the usage of an editor program and results in integrating stand-alone learning objects into a database. The participants can use the database as a shared knowledge resource.

This developmental model applies also to teacher trainees and novices to the teaching profession. For example, at a well-prepared religion lesson in a Romanian school a combination of the traditional frontal lesson and individual work of students could be observed. Traditional methodology was still in use, but the teacher definitely started to apply the features of the VLE system at the 3rd level described above, which means that he approached the learning material and the newly introduced concepts from different viewpoints.

The next step of methodology for making advanced materials require already more organization. To create and work with complex, shared learning material is far more than solely learn about VLE use. To realize the trialogical principle, one needs to create shared materials and utilize / adapt / elaborate on materials and ideas of others. This requires a lot of work and is a time-consuming activity. Based on many experiences with teacher groups we cannot expect that they will work for a long time on a sophisticated VLE system if the leadership of the school doesn't ensure proper conditions for this. One of these conditions is active project management and mentoring of group members.

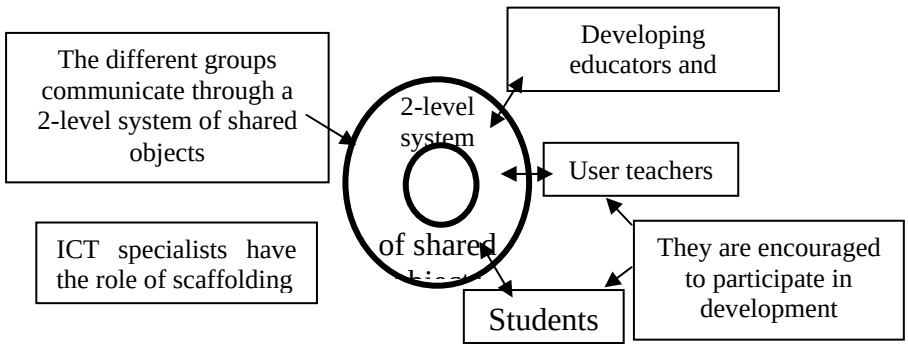
4. Conclusion: Web-based VLE as Organiser of Communities of Practice

Self-regulated learning involves the active participation of students, therefore, the environment should also enable learners to generate new content and adapt existing one for individual needs. *Community based content development and assessment* is inevitable to realise the aim of this VLE: to provide a comprehensive and constantly expanding digital learning content repository [17].

Members of this community are not only educationalists, but also civic associations and companies. The technological framework for the functioning of this community of practice (CoP) is a VLE that offers tools for content development and a sophisticated platform for teaching, learning and assessment. The relatively simple content development component assures that Movelex is used by expert and novice ICT using teachers and students alike. This feature is especially important in Hungary where the level of ICT knowledge and skills of educational stakeholders is extremely diversified. According to the diversity of ICT skill and interest of stakeholders communities have to be organized as Communities of Practice on multiple levels [6]:

- Basic level development is done in small local groups – as described above – using a word processor. The simplest way – suitable even for novices in ICT – is sending the document to each other by e-mail and writing corrections directly into the text.
- Group work for designers on advanced level may be facilitated by a special *networked mode:* here, the software and database is running on the PC of every group member and all of them are linked through the internet. Modifications done by any of them are synchronised and seen by his / her peers.
- The integrated database of LO-s is offered for testing to the final users (teachers and students) who still have a special technique to give feedback to the designers. They can make remarks on any point of a screen layout as if sticking a ticket on it. Designers get back all these remarks integrated, make necessary corrections and issue a new release of the material.
- At advanced level, this response system works as an integrated shared space, as group members can reflect even on each-other's remarks. These are logged by the system in a searchable database documenting this way the evolution of the trialogical developing process.

Summarizing the prerequisites of a successful community of practice among in-service teachers, we consider crucial that trainers and schools of trainees become partners. Best VLE users are those schools where the director definitely supports the project, there are some innovative teachers and the technical background makes possible that the informatics lab can be used for normal (not informatics) lessons. We are building a shared work space which can be illustrated by the following figure:



There is one more additional technical aspect for a successful shared space. Schools – at least in Hungary and Romania – have very different technical infrastructure regarding both ICT labs and access to Internet. The two basic solutions for LCMS are CD ROMs or Web-access to a central server which represent the two extremity: the first one can store lot of data but is very static, on the other hand the Web is limited in terms of quickly accessible data packages, especially if access is through a slower broad-band.

The VLE Movelex works with a special network technology which ensures optimal solution for both high-end, low-end and medium level school infrastructure. Most e-learning materials represent content that does not change often, it is worth to download them. Local use ensures high speed access to large amounts of data, eventual content changes are automatically downloaded and updated. If a high-speed Internet access is available, this synchronization process is very fast, practically works as an on-line system. But speed of on-line access remains always a limit, as the size of data (e. g. videos) is growing very fast as well. With the synchronization system of the Movelex network, users, according to the technical possibilities, can find the optimal ratio of data to be downloaded and those to be used on-line.

This technology enables us to create distributed network systems, where a local group (like a school) can decide whether a given data set should be made accessible only for teachers and students of the school, or stay open towards a higher level server, enriching this way the knowledge base created by a larger, Web-based teacher community of educational content developers.

References

1. Liu, Yuliang, Huang, Carol: Concerns of teachers about technology integration in the USA. European Journal of Teacher Education, 28 (1) (2005) 35-47
2. Venezky, Richard and Kárpáti, Andrea eds.: ICT, Education and Innovation . Special Issue, Education, Communication and Information. Vol. 4, No. 1 (2004)
3. Wood, Allen, Mueller, Judy, Willoughby, Teena, Specht, Jacqueline, Deyoung, Ted: Teachers' perceptions: barriers and supports to using technology in the classroom. Education, Communication, Information, 5 (2) (2005)
4. Leahy, Margaret, Twomey, Denis: Using web design with pre-service teachers as a means of creating a collaborative learning environment. Educational Media International, 42(2) (2005) 143-152
5. Mayer, Richard, Moreno, Roxana: Aids to computer-based multimedia learning. Learning and Instruction, 12 (2002) 107-119
6. Paavola, S., Lipponen, L., & Hakkarainen, K.: Models of Innovative Knowledge Communities and Three Metaphors of Learning. Review of Educational Research 74(4) (2004) 557-576.
7. Bloom, Benjamin S.: All Our Children Learning. New York: McGraw-Hill (1980)
8. Kimber, Kay, Wyatt-Smith, Claire: Using and creating knowledge with new technologies: a case for students-as-designers. Learning, Media and Technology, 31 (1) (2006) 19-34
9. Bruner, J: The Process of Education, Cambridge, Mass.: Harvard University Press (1960)
10. Kirschner, Paul A.: Cognitive load theory: implications of cognitive load theory on design of learning. Learning and Instruction, 12 (2002) 1-10
11. Herrington, Jan – Standen, Peter: Moving from an instructivist to a constructivist learning environment. Journal of Educational Multimedia and Hypermedia, 9 (3) (2000) 195-205
12. Liu, Min, Gibby, Scott, Quiros, Ondrea, Demp, Elaine: Challenges of being an instructional designer for new development: A view from practitioners. Journal of Educational Multimedia and Hypermedia, 11 (3) (2002) 195-219
13. Paavola, S. & Hakkarainen, K.: (2005). The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning. Science & Education 14(6), 535-557.
14. Gros, Begona: Knowledge Construction and Technology. Journal of Educational Multimedia and Hypermedia, 11 (4) (2002) 323-343
15. Kerr, Stephen: Why we all want it to work: towards a culturally based model for technology and educational change. British Journal of Educational Technology, 36 (6) (2005) 1005-1016
16. Kárpáti, Andrea: Travellers In Cyberspace: ICT In Hungarian Romani (Gypsy) Schools. In: Kárpáti, Andrea Ed. (2004): Promoting Equity Through ICT in Education. Paris: OECD (2004) 141-156
17. Hakkarainen, K., Palonen, T., Paavola, S. & Lehtinen, E.: Communities of networked expertise: Professional and educational perspectives. Amsterdam: Elsevier (2004)
18. Amory, Alan, McNaught, Carmel: Collaboration, design and technology – themes in the architecture of interactive learning environments. Journal of Interactive Learning Research, 12 (2/3) (2002) 149-153

Paper 4

Technology-Culture Interaction and Learning Innovations in Asia: An Emergentist View

Jianwei Zhang
Institute for Knowledge Innovation and Technology,
Ontario Institute for Studies in Education of the University of Toronto

Abstract

Drawing on an emergentist view that underlines the micro-macro link in a complex system, this article examines technology-culture interaction in Asia, highlighting the downward influence of the Eastern pedagogical culture on technology as well as educational change emerging from reconciliation of component parts. An important implication of these analyses is teachers' role in adapting technology to their diverse contexts, and improving their practice based on their reflective reconciliation of various factors and demands in education. Deep and sustainable learning technology innovations need to engage teachers as grassroot innovators.

Introduction

In educational technology research, there are growing interests in the influence of cultures on technology design and use and the role of new technology in changing educational culture and practice (Wild, 1999; Lin & Hatano, 2003). Drawing on an emergentist perspective, this article discusses technology-culture interaction in Asia in comparison to its Western counterpart, with the goal of understanding technology use in cultural contexts and identifying important issues in technology-supported learning innovation.

Understanding Technology Effects from an Emergentist Perspective

In earlier research of technology, a large number of studies searched for media effects—whether one medium is better than another in causing effective learning. A conclusion is that comparing the effects of different media is not a productive question for research, because media effects can never be separated from method effects—effects of instructional designs (Kozma, 1994). It is the combination of proper methods, media, and the overall socio-cognitive activities in a context that accounts for effective learning.

Associated with research on media effects, a line of discussion that continues to attract an increasing number of researchers investigates the role of technology in educational change. A critical look at the literature unveils that researchers ask a similar question as media effects, but focusing on technology's effects on teachers and schools: Can new technology cause innovative pedagogical practice or classroom culture? There are studies on both sides showing that using new technologies causes constructivist practices (e.g., Becker & Ravitz, 1999), or technology does not affect teaching practice (e.g., Cuban, Kirkpatrick, & Peck, 2001). A middle-way stance on this issue suggests that technology can be a catalyst (or midwife) of pedagogical change, but technology itself does not cause change (e.g., Lin & Hatano, 2003; Salamon & Perkins, 1996). As Windschitl and Sahl (2002) assert, the influence of technology was mediated in substantial ways by teachers' interconnected beliefs about learners, teaching, and the role of technology within a school context. Although studies on technology and pedagogical change occasionally adopt qualitative methods to capture the richness of classroom contexts in which technology is used; they share the same limitation with media-effect research in problem formulation and underlying beliefs about causality.

Learning technology research has relied too much on an analytic approach focusing on resultant and "mechanical" effects, attempting to tease out isolated factors (e.g., software) that cause effective learning and educational change. Recent development of emergentism in social science research provides an alternative framework, which considers a social organization/entity as a complex system and underlines the micro-macro link in a complex system by delineating two types of causations. *Supervenient causations* refers to the bottom-up emergence of more complex, "higher level" structures from the organization and interaction of simpler, "lower level" component parts. *Downward causations* represents the significant influence of the overall system organization on the function of any component (Sawyer, 2003). A pedagogical culture carried by an identifiable community is reflected in people's collective, intuitive understanding of what education is about and how it should be approached. It can be considered as a complex system consisting of interconnected component parts, including: (a) beliefs about desirable human qualities, learners, knowledge, and good learning and teaching; (b) approaches to learning, teaching, and assessment; (c) social organization of

schooling; (d) learning resources and technological tools (cf. Fullan, 2001). The constant evolution of a pedagogical culture is the emergent result of the complex interactions of its components—their supervenient causations. This evolution cannot be fully predicted, and may not be attributed to any one of the components in a reductionist way. For example, education in modern China differs in many important ways from its ancient mode after it evolutionarily incorporated new elements in educational beliefs, pedagogical approaches, organizational systems, and technologies. On the other hand, an existing pedagogical culture also has significant downward causal influences on its components. A pedagogical culture as a whole shapes the needs for technologies as well as the way educators understand and use technologies. This leads to the fact that educators often choose "domesticated technologies" that do not affect life in the classroom much (Salomon & Almog, 1998). A teacher-centered classroom culture can be maintained when new technologies (e.g., computers) and strategies (e.g., cooperative learning) are used. This can be explained by the "multiple realizability" of a complex system, indicating that a social property can be realized through multiple mechanisms at the component level (Sawyer, 2003).

The above two types of causations manifest in educators' thinking and ultimately in educational processes enacted by teachers and students. The processes of technology-culture interaction often take place implicitly without our clear awareness. A way to observe these processes is through the lens of cross-cultural comparison. Drawing on an emergentist perspective, this article reflects on the interaction between culture and technology in Asia that has a distinctive culture, specially focusing on two issues: (a) The downward causal influence of the Eastern pedagogical culture on technology use, and (b) the realignment of technology with other factors in the process of change.

How Does the Eastern Pedagogical Culture Shape Technology Use?

Rooted in Confucian philosophy, the Eastern culture embraces a dialectical and holistic world view, perceiving human beings and nature as one unified entity, considering the interdependent relationship between living things and their environment, the natural and human elements, and their mutual shaping in the construction of meaning (Chen, Mashhadi, Ang, & Harkrider, 1999; Nisbett, 2003). The Eastern tradition seeks harmony, order and well-being in a society by underlining social obligations of individuals and classes, who should behave in line with the social expectations of their

social roles, spanning from seniors to young children, from governors to common citizens, for both male and female (Huang, 2002). Hence Easterners are more in favor of collectivism, urging individuals to surrender their own genuine interests for the sake of the well-being of the collectivity, being that a family or a state (Huang, 2002). This cultural tradition, together with other social factors such as economical structures, political systems and population pressures, has shaped a group-based, teacher-dominated, and centrally organized pedagogical culture. These features are elaborated in Figure 1 (Zhang, in press).

Insert Figure 1 about here

A typical image of an Eastern classroom involves a teacher conducting expositive teaching in front of a large class of well-disciplined students, seated in rows. However, this does not necessarily mean that teachers merely "feed" knowledge to learners passively. Qualified teachers tend to model responsible learning behaviors; stimulate learners' thinking and reflection by asking thought-provoking questions; design and use informative assignments to promote understanding and integration of knowledge; use a variety of strategies to adapt to the different needs and backgrounds of learners; and forge personal relationships with students and their families. In parallel, self-engagement and reflection are conceived as core qualities of a good student (see also, Jin & Cortazzi, 1998; Lee, Liu, & Lee, 2003; Stevenson & Stigler, 1992). In a study, Jin and Cortazzi (1998) compared the responses of Chinese and British students on a variety of attitudinal items. When asked what constitutes good teaching, Chinese students were more likely than British students to define a good teacher as someone with deep knowledge who sets a good example and teaches students about life. British students were significantly more likely to define a good teacher as someone who is helpful, sympathetic to individual students, and who arouses their interest and organizes a variety of classroom activities. In terms of the characteristics of a good student, Chinese respondents were significantly more impressed by students who respect the teacher, study spontaneously, develop a good character, answer the teacher's questions, ask questions during and after class, and prepare for the class in advance.

To boost up educational reform and development, Asian countries are keen to integrate technology in teaching and learning. China launched the "Connecting-Every-School" project in 2000. The student/computer ratio improved from 121:1 in 1999 to 27:1 in 2004. Other nations are also implementing their master plans for incorporating information technology in education (Zhang, in press). As noted above, a pedagogical culture as a complex system tend to have downward causal effects on its components, among which are technological resources and tools. These effects can be observed in the ways technologies are selected, designed, and used in Asian education. The below elaborates two compelling examples.

Using Technology for Expository, but Reflective Teaching

As noted earlier, Eastern societies have a group-based, teacher-dominated, centrally organized pedagogical culture. Expository teaching is the most frequently used method, particularly in curriculum components where the primary objective is the students' mastery of standardized facts, concepts, rules and procedures, or when the objects of learning and/or resources available are thought to be too complex to be understood by the learners (Law, Yuen, Ki, Li, Lee, & Chow, 2000). Within this cultural background, computers have been used to support expository teaching in large classes, including after-school assignments. As a result, teachers prefer content-bound and curriculum-compliant courseware and resources (Zhang, 2002). In the 1980's and early 1990's, the dominant types of software were PC-based tutorials, drills-and-practices, and computer-assisted tests; while more recently, they have evolved to multimedia-based resources databases and Web-based gateways, which sort learning resources in line with the national curriculum. A typical example is the China Basic Education Resources Network (http://www.cbern.gov.cn/index.html), which hosts and sorts learning resources according to grade levels, subject areas, and types (e.g., assessment tools, reading materials, tutorials). The need for these resources is reinforced by the culture of examination that brings about high pressures to students, teachers, and parents. In contrast, in the Western learning culture that is more learner-centered, activity-focused, and individualized, technology is more likely to be used as content-open productivity tools (e.g. word processing, simulations, explorative environments, graphics, spreadsheet, database, presentation) (Becker, Ravitz, & Wong, 1999).

The focus on expository teaching in Asia also shapes hardware configurations. An earlier international comparison showed that more than 50% of the middle schools in Hong Kong had digital projectors or LCD display boards, much higher than the average ratio in other regions. This reflects the needs of the schools to assimilate technological tools in service of teacher-directed demonstrations and lectures in classroom (Law, Yuen, Ki, Li, & Lee, 1999).

The Eastern culture values reflection. As Stigler and colleagues observed, qualified East Asian teachers tend to guide learners' active reflection during expository teaching (Stevenson & Stigler, 1992). This also has a visible influence on their technology use. As international comparisons of classroom teaching indicated, while overhead projectors had largely substituted blackboards in American classrooms, Japanese teachers preferred to use blackboards, even though overhead projectors were widely available. One reason lies in the advantage of blackboards in keeping records of classroom interactions and promoting students' reflection (Stigler & Hiebert, 1999). This emphasis on reflection can be similarly observed in computer-based learning environments. A combination of teacher expertise and computer technology helps engage students in an increased level of reflection. For example, a primary mathematics teacher in Beijing uses quite common tutorial and drill-and-practice courseware to aid teaching of word problem solving. She intentionally prompts her students to think ahead of the tutorial program by asking them to "predict" what the computer will explain next; and promotes students' reflection on the underlying mathematical principles and relationships by clustering a series of word problems in drill-and-practice courseware as interrelated variations.

Adaptations of Distance Learning

Many Eastern societies face a pressure of greatly increased population numbers. Many of them are highly motivated to use technology to increase the participation ratio of education, especially higher education, through distance learning programs. China launched the Modern Distance Education Project in 1999 aimed at promoting lifelong learning. So far, more than sixty prestigious universities have been involved in this project to establish Web-Based Education Schools, offering distance learning programs spanning vocational training and undergraduate and graduate education. The Vietnamese government has also been encouraging more flexible modes of delivery in higher education. In the early 1990's, enrolments in informal and flexibly-delivered courses (including distance education and part-time studies) in Vietnamese higher education institutions rose much faster than enrolments in full-time, on-campus programs. There were around 50,000 students enrolled in distance education at the university level in Vietnam in the late 1990s (Le & Tran, 1999) and this number has been growing rapidly. Distance learning is also chosen as a way to improve learning opportunities in Japan, which had 250,000 to 300,000 distance learners in 2000 (Albrechtsen, Mariger, & Parker, 2001).

Distance learning was invented in the Western world as a bond of learning approach and technology rooted in the belief of individual and open learning. Since it was imported into the Eastern world, distance learning has been adapted in many aspects in response to local pedagogical beliefs and approaches, social structures, and technological conditions. Unlike the individualized, self-paced learning models and materials adopted by distance learning institutions in UK and other Western nations, distance learning in China has been localized as group-based distance lecturing (see also, Tu & Twu, 2002; Zhu, Gu, & Wang, 2003), which organizes learners into classes at local learning centers to attend lectures. These are delivered through television, VCD/DVD, satellite-based digital video broadcasting, videoconferencing systems, or Internet-based video/audio streams synchronized with PowerPoint slides. Contrary to the expectation that Chinese teachers cannot lecture and dominate learning any more in a Web-based environment (Lee, 2004), they naturally extend group-based lecturing into the virtual world. Interestingly this approach seems to be in accordance with the expectation of Asian learners. According to a survey among distance learners in undergraduate and graduate programs, 85 percent of the learners agreed that it is important to study in a classroom together with their classmates, and a majority of them stressed the importance of face-to-face interactions with teachers (Zhang, Wu, & Li, 2003). This result is consistent with observations of students in Korea (Jung, 2000) and South East Asia (e.g., Malaysia) (Ziguras, 2001). It is almost impossible to identify who first made the above adaptations/reinventions; they seemed to have come out of a collective process in which designers, instructors, and students all played important parts.

As the above analyses revealed, the Eastern pedagogical culture has significant influence on the emergent needs, selection, understanding, design, and use of technology. This influence is realized through educators' efforts to build deep connections between new technologies and ongoing educational practices in their local contexts, fostering the historical descending of their pedagogical culture.

Realigning Technology and Other Factors in Reforms

In addition to serving the needs of existing educational practice, recent educational technology research has been seeking transformative change in education (Cox, 2007, this session). An emergentist view implies that the change of a pedagogical culture is not caused by any one component, but the complex interactions of all its components. This coincides with Fullan's (2001) stresses on coherence, alignment, and connectedness of educational reform programs. For a reform to succeed, the reform program *per se* must be coherent in the sense that its components must be well connected and aligned with each other. What I want to highlight additionally is that coherence is a process that needs to be accomplished by teachers—instead of only program designers—through reflective reconciliation of multiple factors and demands in specific learning and teaching contexts. No matter how well a reform program is planned, teachers will inevitably face a variety of discrepancies and conflicts in their reality. This is the dynamic, multifaceted nature of classroom processes. The ways teachers cope with these discrepancies and conflicts have a determinant effect on what changes the reform can lead to.

Influenced by the belief in the authoritativeness of knowledge, East Asian nations have historically emphasized knowledge transmission in education. Facing the challenge of the Knowledge Age, these nations are determined to use new technologies to promote active and innovative learning (Ziguras, 2001). Student inquiry, problem solving, collaborative project work, authentic activities, and knowledge creation become the tenet words in recent educational reforms (Mizukoshi, Kim & Lee, 2000; Hung & Chen, 2003). The new curriculum reform in China represents an example of systemic reforms in this regard. Since late 1990's, China has been committed to a shift from examination-oriented to "quality-oriented" education. As a key action, the Ministry of Education developed the New National Curriculum Standards in Basic Education (i.e., Grade 1-12). This reform embraces new pedagogical beliefs (e.g., constructivism), principles/strategies (e.g., collaborative inquiry, portfolio assessment), social and organizational norms (e.g., decentralizing curriculum management), and tools and resources (e.g., new textbooks and resources, information tools). Information technology is of particular concerns in this reform both as a subject area and as learning tools integrated across the curriculum. The new curriculum reform is making noticeable changes in classrooms (Ma & Tang, 2003). However, teachers experience deep conflicts and discrepancies in implementing the new curriculum. Wide concerns arise among teachers regarding the difficulty of completing the required curriculum content through inquiry-based strategies within limited class hours; challenges of organizing inquiry activities in large, crowded classes; shortage of accessible, high-quality learning resources particularly in rural schools; challenges associated with student management in technological environments; weakness of activity-based learning in grasping systematic knowledge, which has been traditionally emphasized in China; and possible failures in high-stake public examinations. Teachers have to cope with these discrepancies and conflicts and make decisions that balance different demands in their specific contexts. Quite a few teachers adopt a strategy of "superficial dialectics:" they use new technologies and conduct participative and inquiry-oriented classes in their demo and open lessons shown to inspectors, but maintain traditional teaching in daily routine. Students are even asked to find the old version textbooks as additional learning materials. A better, more demanding strategy features a "deep dialectics" approach, which is often used by teachers who have been more

voluntarily engaged in classroom change. These teachers try to understand new opportunities provided by the new curriculum and related technologies; balance the strength and weakness of traditional and innovative learning; and select optimal approaches according to specific conditions such as domain of learning, students' prior knowledge, resources available, and so forth. When they need to use expository teaching, they try to make this traditional method more interactive and participative. Both the superficial and deep dialectic strategies can help teachers re-build the alignments of different facets in their practical contexts; apparently, the latter is more conductive to the progressive improvement of a pedagogical culture, as opposed to "fashion change" of pedagogy (Bereiter, 2002). Through deep, reflective reconciliation of various facets in education, teachers achieve new professional understanding and evolve classroom designs that capitalize on the potentials afforded by new technologies, ideas, and social organizations. They selectively retain good practices in existing education while overcoming its limitations. Promote a deep, constructive approach to conflict resolving among teachers requires engaging teachers more deeply in reforms and recognizing their innovative role.

Implications: Engaging Teachers' Innovative Capacity and Agency

In sum, this article applies an emergentist view to examining technology-culture interaction in Asia, highlighting the downward influence of the Eastern pedagogical culture on technology as well as educational change emerging from reconciliation of component parts. This emergent, cultural perspective helps us understand the complex processes of technology adoption, adaptation, and learning innovation in different social contexts. An important implication of the above analyses is teachers' role in adapting technology to their diverse contexts, and improving their practice based on their reflective reconciliation of various factors and demands in education. As Lin and Hatano (2003) put it, "teachers and students adapt technology to meet their diverse classroom needs, while adapting their educational practices to take advantage of the afforadances offered by the technology—a bi-directional adaptation process." (p. 5) The adaptation and reconciliation processes call for teachers' innovative capacity and agency in seeking better professional understanding, envisioning new opportunities, identifying and breaking barriers in their contexts, and re-designing learning processes. However, in most learning technology innovations developed by researchers and governmental agencies, teachers are seen as "users" who implement the innovations in their classrooms, with the goal of maintaining high fidelity (Penuel & Means, 2004). A technology innovation program typically includes a technology package providing technological tools and resources and an activity package specifying the procedures and activities (e.g., pre-designed projects) to be carried out using technology. Correspondingly, teacher training in these programs focuses on delivering "how-to" knowledge needed to implement the programs, including how to use the technology and how to organize and facilitate the activities, with little support to help teachers adapt the program to meet the local needs of their classroom contexts (Barab & Luehmann, 2003), realign the innovation with key facets of their profession, and evolve new designs and practices in light of the spirit of the innovation. An emergentist view suggests that educational progresses emerge from reflective creativity at the bottom levels (see also, Sawyer, 2004). Deep and sustainable

learning and technology innovations need to engage teachers as grassroot innovators who can appropriate the principles and technologies underpinning an innovation, connect them to their local contexts, bridge gaps, and commit to reflective and continual improvement. A research I'm conducting with my colleagues is to understand whether this is possible and what kinds of efforts teachers need to make to play their innovative role, with promising preliminary findings (Zhang & Scardamalia, 2007). Engaging teachers' innovative capacity and agency in learning technology innovation represents a challenge for both the Eastern and the Western societies, although the specific cultural contexts and barriers vary. Addressing this challenge in different cultural contexts should be a top issue for educational technology research.

References

Albrechtsen, K., Mariger, H., & Parker, C. (2001). Distance education and the impact of technology in Europe and Japan. Educational Technology Research and Development, 49(3), 107-115.

Barab, S. A. & Luehmann, A. L. (2003). Building sustainable science curriculum: Acknowledging and accommodating local adaptation. Science Education, 87(4), 454-467.

Becker, H., & Ravitz, J. (1999). The influence of computer and Internet use on teachers' pedagogical practices and perceptions. Journal of Research on Computing in Education, 31(4), 356-385.

Bereiter, C. (2002). Education and mind in the knowledge age. Mahwah, NJ: Erlbaum.

Cox, M. (2007). The changing nature of researching IT in education. A paper to be presented in the symposium: "Global Perspectives on Technology as a Change Agent in Teaching and Learning Identified by Educational Researchers in the International Federation of Information Processing" at the Annual Meeting of American Educational Research Association, Chicago, IL.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms. American Educational Research Journal, 38(4), 813-834.

Fullan, M. (2001). The New Meaning of Educational Change (3rd edition). New York: Teachers College Press.

Huang, X. (2002). What is "Chinese" about Chinese civilization? In: M. Mozaffari (Eds.), Globalization and civilizations (pp.218-241). London: Routledge.

Hung, D., & Chen, D.T. (2003). Online learning and information technology in the Asia-Pacific region. Educational Technology, 43(3), 5-9.

Jin, L., & Cortazzi, M. (1998). Dimensions of dialogue: large classes in China. International Journal of Educational Research, 29, 739–761.

Jung, I. (2000). Technology innovations and the development of distance education: Korean experience. Open Learning, 15 (3), 217-231.

Kozma, R.L. (1994). Will media influence learning? Reframing the debate. Educational Technology Research and Development, 42 (2), 7-19.

Law, N., Yuen, H. K., Ki, W. W., Li, S. C., & Lee, Y. (1999). Second international information technology in education study: Hong Kong SAR report. Online available at: http://sites.cite.hku.hk/full_report.htm

Law, N., Yuen, H. K., Ki, W. W., Li, S. C., Lee., Y, & Chow, Y. (2000). Changing classrooms and changing schools: A study of good practices in using ICT in Hong Kong schools. SITE Hong Kong Study Centre, Faculty of Education, The University of Hong Kong. Online available at: http://sites.cite.hku.hk/Changing_blue_book.htm.

Lee, D. (2004). Web-based instruction in China. Educational Technology Research & Development, 52(1), 101-105.

Lin, X., & Hatano, G. (2003). Technology, culture, and adaptive minds. Mind, Cultures, and Activity, 10(1), 3-8.

Ma, Y., & Tang, L. (2003). A questionnaire survey analysis of the basic education curriculum reform. Guangming Daily, June, 19 (in Chinese).

Mizukoshi, T., Kim, Y., & Lee, J. Y. (2000). Instructional Technology in Asia. Educational Technology Research and Development, 48 (1), 101-112.

Nisbett, R. E. (2003). The Geography of Thought. New York, NY: Free Press.

Penuel, W. R., & Means, B. (2004). Implementation variation and fidelity in an inquiry science program: Analysis of GLOBE data reporting patterns. Journal of Research in Science Teaching, 41(3), 294-315.

Salomon, G., & Almog, T. (1998). Educational Psychology and Technology: A Matter of Reciprocal Relations. Teachers College Record, 100(2), 222-241.

Salomon, G., & Perkins, D. (1996). Learning in Wonderland. In Kerr, S. T. (Eds.), Technology and the future of schooling (pp.111-129). Chicago, IL: National Society for the Studies in Education.

Sawyer, K. (2003). The mechanisms of emergence. Philosophy of the Social Sciences, 34(2), 260-282.

Sawyer, R.K. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. Educational Researcher, 33(2), 12-20.

Stevenson, H. W., & Stigler, J. (1992). The Learning Gap. New York, NY: Summit Books.

Stigler, J. & Hiebert. J. (1999). The Teaching Gap. New York, NY: Free Press.

Tu, C.H., & Twu, H. L. (2002). Educational technology in Taiwan. Education Media International, 39(2), 153-164.

Wild, M. (1999). Accommodating issues of culture and diversity in the application of new technologies. British Journal of Educational Technology, 30 (3), 195–199.

Windschitl, M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school. American Educational Research Journal, 39(1), 165-205.

Zhang, J. (2002). Incorporating ICT into K-12 schools. TechTrends, 46(4), 51-57.

Zhang, J. (in press). A cultural look at information and communication technologies in Eastern education. Educational Technology Research and Development.

Zhang, J. & Scardamalia, M. (2007). Sustaining principle-based knowledge building innovation at an elementary school. A paper presentation at the Annual Meeting of American Educational Research Association, Chicago, IL.

Zhang, J., Wu, G., & Li, F. (2003). The current state of e-learning under implementation. Open Education Research, (4) (in Chinese).

Zhu, Z., Gu, X., & Wang, Q. (2003). A panorama of online education in China. Educational Technology, 43(3), 23-27.

Ziguras, C. (2001). Educational technology in transnational higher education in South East Asia. Educational Technology & Society, 4(4), 8-18.

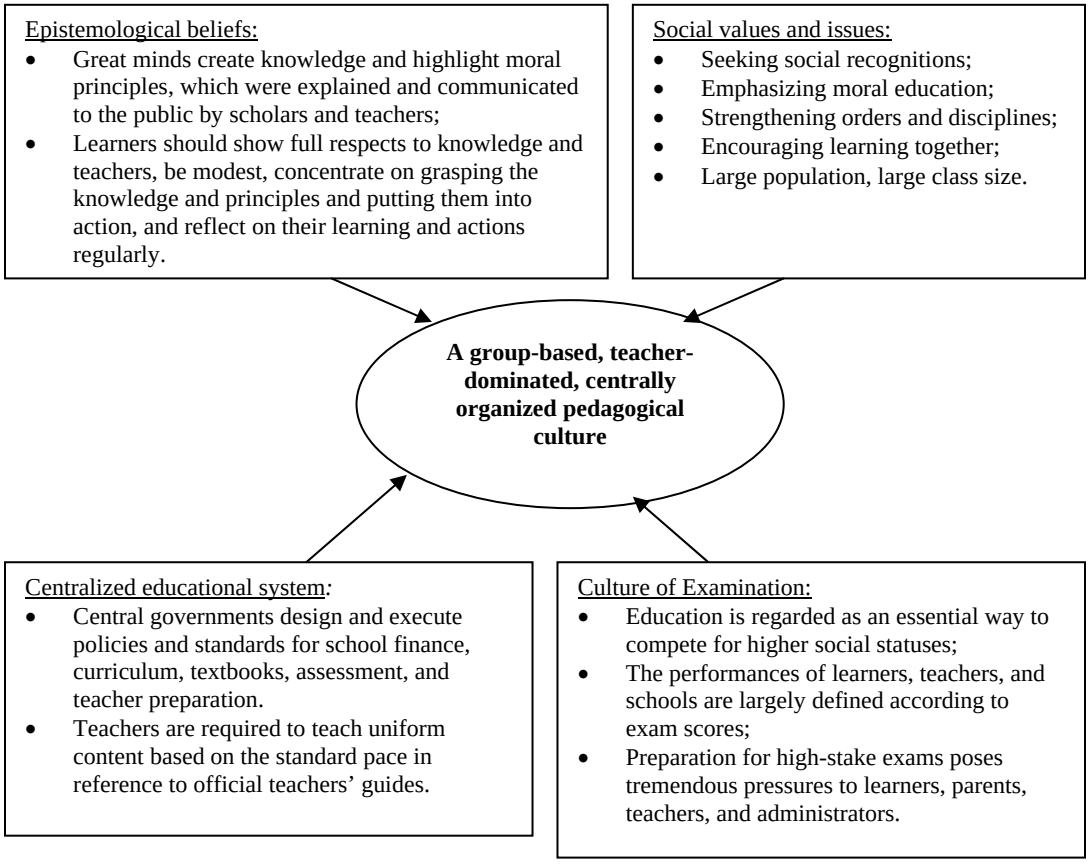


Figure 1. Basic features of the Eastern pedagogical culture (from Zhang, in press).