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INFORMATION TECHNOLOGY ISSUES IN EDUCATION (2000-2002)

A Master's Paper

by

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Chapter 1

Introduction

Objective of the Paper

Information technology (IT) has advanced rapidly over the last few years and there have been hundreds of published studies investigating its educational effect. The objective of the paper is to review the current research issues that information technology presents for education. Due to more and more creative and research-based applications of information technology in education, research papers with respect to this area are important for improving teaching and learning with information technology.

Background

Information technology (IT) refers to all forms of technology applied to processing, storing, and transmitting information in electronic form. Computers, communications equipment and networks, fax machines, and electronic pocket organizers are the physical equipment used for this purpose (Lucas, 2000). Since information technology is changing quickly with more innovative and sophisticated features available for us at a decreasing cost, advances in computing and communication technology have

created a new infrastructure for business, social interaction, and scientific research. Information technology, which provides us with new tools for communicating throughout the world and for acquiring knowledge from information, is transforming the way we live, learn, work, and play.

According to Lucas (2000), education is one of the many issues regarding the impact of information technology on individuals, the organization, and society. Is our educational system preparing students for the technology they will face as adults? Since advances of information technology are revolutionizing the educational process, schools will need to redesign and develop new curricula in which the capabilities of technology are exploited to provide new ways of learning. Up until now, information technology has not only enhanced "on campus" education and facilitated distance learning through videoconferencing, e-mail, electronic meetings, groupware, electronic guest lectures, but also provided access to amounts of reference material and facilitated collaborative projects regardless of time zones and distance.

Information technology issues in education can be discussed in various dimensions, like delivering tools, institutions, and processes. Considering the range of issues and their number, writing a fully comprehensive review on this topic would be impractical. For this reason, this paper reviews and summarizes papers from the journal *Education and Information Technologies* ranging from 2000-2002.

Education and Information Technologies is the official journal of the IFIP's Technical Committee on Education (called TC3, established in 1963). IFIP (International Federation for Information Processing), founded in 1960 under the auspices of UNESCO, is a multinational federation of professional and technical organizations concerned with

information processing. This quarterly journal publishes papers from all sectors of education on all aspects of information technology and information systems starting from early 1996. Focusing on the issues of information technology, topics covered in this journal include changes and examples of good practice and innovative ideas in teaching and learning. Therefore, I choose this journal as my primary references for literary review to identify research issues in this field.

Research Process

Mertens (1998) provides a general outline for conducting a literature review. The steps in the literature review process are summarized as follows:

1. Identify a research topic
2. Review secondary sources to get an overview of the topic
3. Develop a search strategy
4. Conduct searches and select titles
5. Obtain sources
6. Read and prepare bibliographic information and notes
7. Evaluate the research reports
8. Analyze the research findings and synthesize the results
9. Use the synthesis to develop a conceptual framework, research questions, and/or hypotheses

This paper is conducted to provide a comprehensive understanding of what is known about IT issues in education. Following the steps in the literature review process (Mertens, 1998), I first identified my research topic and reviewed secondary sources to get an overview of the topic.

Second, I developed a search strategy, conducted searches, and selected titles. After identifying the primary research journal that publishes articles related to my topic, I selected the preliminary sources that contain the best information on my topic. The retrieval process of these papers involved searching the library databases such as CAT and INSPEC. In the INSPEC database, I entered "Education and Information technologies" in search for the exact publication title. There are 121 records that matched the search. Those records are the papers published in the journal of *Education and Information Technologies* from March 1996 to March 2002. It is noted that there are three more issues yet to be posted in INSPEC.

Third, I obtained the sources as well as read and prepared bibliographic information and notes. All the papers ranging from 2000 to 2002 were marked, and the marked list was downloaded in the Endnote (Citation + Abstract) style. Afterwards, the downloaded list file was imported to the Endnote library created for references. The software automatically built those references in APA format. As for the missing three issues, the website of the publication company for this journal (http://www.kluweronline.com/) was searched. Most of the articles published in this particular journal can be found in full-text from 1997 to 2002. According to the online information provided, the missing articles were entered using the Endnote software.

Fourth, the research papers and their findings were evaluated, analyzed and synthesized. Then a conceptual framework was developed accordingly to lead the review process. With regards to the research writing, a Penn State Thesis Package for Microsoft Word (the PsuThesi software) was used to create the format of this paper. After installing the software and the initial setting process, the thesis files will be created according to the settings, which can facilitate the following thesis writing process.

Chapter 2

Literature Review

The papers that I reviewed represent a range of studies: in terms of education system level – from early childhood to adult education, in terms of instructional systems development process – from analysis to evaluation, and in terms of technology- from multimedia to the Internet. The research methods of these papers vary from statistical to qualitative analysis.

The first section outlines the education system level analyzed in the literature. The second section introduces the phases of the instructional systems development process. The third section examines the research methods. The fourth section provides the classification for IT applications in a learning-related context. The last section discusses IT issues in education by relating to the previous sections in tables and summarizes the reviewed papers in this field.

Educational system levels

The first classification scheme for classifying articles based on their education system level or learning setting was adapted from several resources.

First, IFIP Technical Group 3 (Education) currently sets up seven working groups, which bring together professionals in many different domains of education: in

teacher education, in curriculum and instruction for elementary and secondary education, in administration and policy making, in computer science education at the secondary and higher-education levels, in research, and in the application domain of distance education. The seven working groups of IFIP TC3 include WG 3.1 (Secondary Education), WG 3.2 (Higher Education), WG 3.3 (Research), WG 3.4 (Professional and Vocational Education), WG 3.5 (Elementary Education), WG 3.6 (Distance Learning), and WG 3.7 (Educational Management).

Second, every country has its own education system structure. According to the working groups of IFIP TC3 mentioned above as well as the structure of education system that the U.S. Department of Education provides, the analysis of educational system level in this paper is as follows (Figure **2-1**):

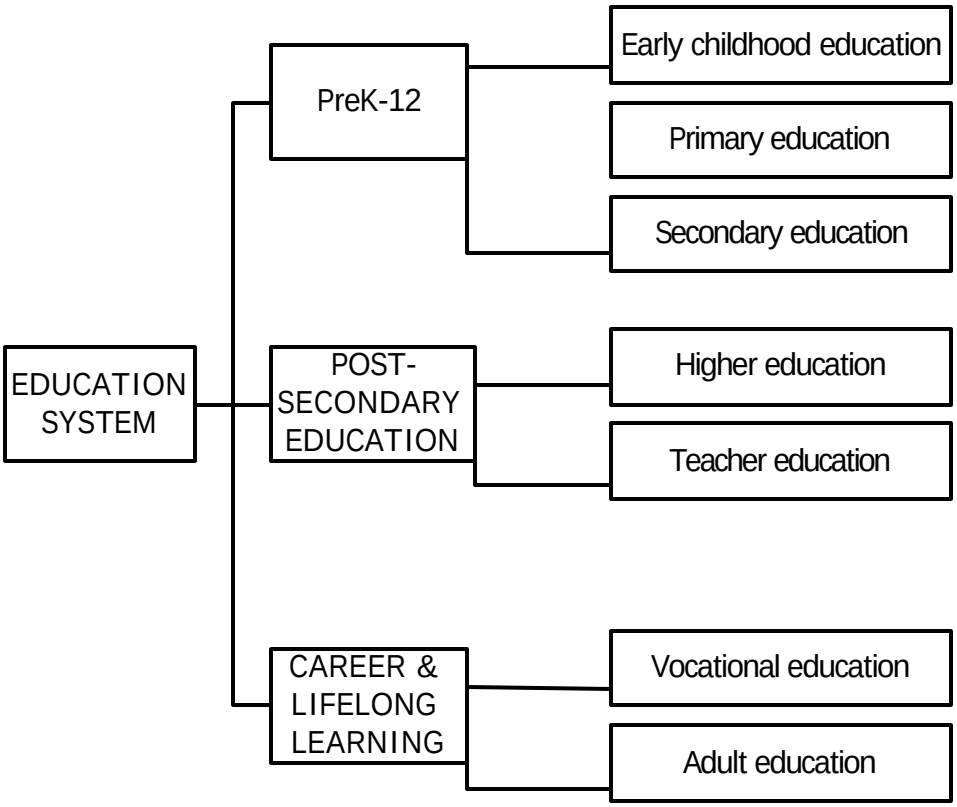

Figure **2-1**: The basic structure of an education system

Instructional Systems Development (ISD) process

The set of classification is adapted from the basic ISD model (Piskurich, Beckschi, Hall, & American Society for Training and Development., 2000). The overall ISD process consists of the following phases: analyze, design, develop, implement, and evaluate (ADDIE, see Figure **2-2,** Piskurich et al., 2000, p. 41). In addition, the design and development methodologies for digital learning material described in Adelsberger,

Collis, and Pawlowski (2000) follow the similar process as well. The ISD model phases and its procedures are displayed in Table 2-1 (adapted from Piskurich et al., 2000, p. 41).

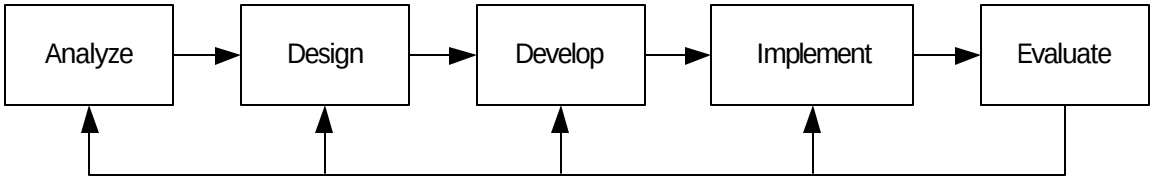

Figure 2-2: ISD model phases

Table 2-1: ISD model phases and their procedures

ISD model phases	Procedures
Analyze	Analyze job; Select tasks/functions; Construct performance measures; Analyze existing courses; Select instructional setting
Design	Develop objectives; Develop tests; Describe entry behavior; Determine sequence and structure
Develop	Specify learning events/activities; Specify instructional management plan and delivery system; Review/select existing materials; Develop instruction; Validate instruction
Implement	Implement instructional management plan; Conduct instruction
Evaluate	Conduct internal evaluation; Conduct external evaluation

It is noted in Figure 2-2 that ISD seems to be a linear system; however, it is best utilized as an interactive process in which sequencing and fine-tuning objectives are possible (Piskurich et al., 2000). Piskurich et al. (2000) explained each ISD phase as the following.

Basically, the analysis phase is dedicated to the collection of data. The data collected in the first step of the ISD process will help determine whether there is a need for instruction, what will be taught, and what behaviors and processes the learner should exhibit.

Next, the first activity in the design phase is to construct terminal learning objectives for each task. And criterion-referenced test items are written to satisfy the needs for entry tests, pretests, unit posttests, or end-of-course tests. Then objectives and learning steps should be arranged in the sequence in which instruction is presented to the learner. Relationships among learning objectives should also be examined in this phase.

After the data, objectives, and tests have been established, how to translate these into learning events and activities is the task of the development phase. Then the actual conduct of the instruction should make most of the non-instructional aspects of implementation transparent to the learner. Finally, the progress and performance of both instruction and the students is measured in the evaluation phase.

Research methods

Based on the nature of data collected, research methods can be classified into quantitative approach, qualitative approach, and mixed method. The quantitative approach collects and analyzes quantitative data in the research process. On the other hand, the qualitative approach collects and analyzes qualitative data in the research process. Quantitative data are information about the world in the form of numbers, whereas qualitative data are mainly information about the world in the form of words. Both types of data are combined if the mixed method is used. Table **2-2** lists some basic characteristics of the quantitative and qualitative approaches. It should be noted that each of these characteristics is more a matter of a range of positions than a simple contrast (Mertens, 1998; Punch, 1998).

Table 2-2: Basic characteristics of the quantitative and qualitative approaches

	Quantitative Research	**Qualitative Research**
Research Questions	Prespecified research questions	General guiding questions
Research Design	Tightly structured design	Loosely structured design
Context	The investigation of artificial settings	The investigation of nature
Focus	Focus on behavior	Focus on meaning
Generalization	Deductive approach	Inductive approach
Objective	Seeking scientific laws	Identifying cultural patterns
Data	Prestructured data	Data not prestructured
Data Collection	Quantitative data	Qualitative data
Data Analysis	Variable-oriented analysis	Case-oriented analysis
Data Collection Methods	Survey questionnaire	Interview Observation Participant observation Document and records review
Research Methods	Correlational research Multiple regression Survey research Causal comparative research Experimental research Quasi-experimental research	Ethnographic research Case studies Phenomenological research Grounded theory Participative inquiry Clinical research Focus groups

To be more specific, as Punch (1998) indicated, the quantitative approach conceptualizes reality in terms of variables and relationships between them.

> It rests on measurement, and therefore pre-structured data, and usually research questions, conceptual frameworks and design as well. Samples are typically larger than in qualitative studies, and generalization through sampling is usually important. It does not see context as central, typically

> stripping data from their context, and it has well developed and codified methods for data analysis. (Punch, 1998)

However, the qualitative approach deals more with cases. It is sensitive to context and process, to lived experience and to local grounded-ness, with which the researcher tries to get closer to what is being studied.

> It aims for in-depth and holistic understanding in order to do justice to the complexity of social life. Samples are usually small, and its sampling is guided by theoretical rather than probabilistic considerations. Pres-structuring of design and data is less common, and its methods are less formalized than those in the quantitative approach. They are more multi-dimensional, more diverse, and less replicable. (Punch, 1998)

IT applications in education

Technologies can be classified in a variety of ways. In order to organize a discussion of information technology in education, Adelsberger et al. (2002) illustrate one approach which focuses on the software products in terms of categories relating to their educational use. The eight IT categories classified by their application type include software for knowledge transfer and conceptual development, applications for communication support, applications for collaborative learning, software for conceptual manipulation, educational databases, tools, web-based integrated resources, and non-web systems. More detailed descriptions about IT applications in education are shown in Table 2-3.

Since technologies are changing very quickly, more and more IT applications are web-enabled. It's also a trend that several technologies are integrated into a package or system. Therefore, it is noted that the categorization in the following discussion is not mutually exclusive.

Table 2-3: IT applications in education

IT applications	Definition
Software for knowledge transfer and conceptual development	Include exemplars as diverse as tutorials, drill-and-practice, integrated learning management systems, some simulations Java applets, web-based course support sites, and video-on-demand lecture presentations
Applications for communication support	Programs that support communication in different forms, such as word processing software, email tools and systems, computer conferencing applications, web-boards, chat and MOO tools, and audio and video conferencing applications
Applications for collaborative learning	Include shared workspaces, specially-made systems to support collaborative work, and tools such as workflow. All the communication applications can also be used to support collaboration
Software for conceptual manipulation	Tools to manipulate representations of concepts in order to come to a deeper understanding of the concept include simulations, virtual reality systems, microworlds, concept mapping tools, and workbenches
Educational databases	Include hypercard for user-designed and filled databases, multimedia CD-ROMs for large collections of professionally assembled multimedia resources, and web-based course management systems
Tools	Tools for self-expression and for the self-creation of learning and performance-support materials, such as HTML editors, PowerPoint presentation, search tools and agents
Web-based integrated resources	The integration of various sorts of software products into an environment that seems to the user to be a single integrated system, accessible via the same user interface
Non-web systems	Systems for educational and performance-support, such as integrated-software systems, task-support systems, wide area systems involving the combination of data networks, telecommunication, and mass communication along with different human/organizational services aimed at educational institutions

IT issues in education

Based on the IT categories in education provided by Adelsberger et al. (2002), I combine web-based integrated resources and non-web systems into one category. Since the papers that I review discuss the above two categories in a general topic called Information and Communication Technologies (ICT) instead, seven major IT issues in education will be included in the following discussion. Each issue will be further classified into several topics considering different technologies are exploited.

1. Software for knowledge transfer and conceptual development
2. Applications for communication support
3. Applications for collaborative learning
4. Software for conceptual manipulation
5. Educational databases
6. Tools
7. ICT

According to the topic, keywords and content of each paper, IT issues in education can be identified in the above seven areas. The contents are summarized in Tables 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, which are the results of IT issues discussed in the education field. So far, three data fields are attributed to each paper in these tables: column 2 gives information of the educational system level with which the paper is associated; column 3

is the ISD phases which the paper examines; column 4 is the research methods conducted in the paper.

Software for knowledge transfer and conceptual development

This section addresses the IT issues in education regarding software for knowledge transfer and conceptual development, such as tutorials, drill-and-practice, integrated learning management systems, some simulations Java applets, web-based course support sites, and video-on-demand lecture presentations.

The Internet is a network of networks. In other words, the Internet is a worldwide network linking millions of users on their own networks (Lucas, 2000). So far, it has been widely used for exchanging information. A lot of applications have been developed using the Internet. World Wide Web (WWW) is one of the key applications. WWW refers to a series of links among related topics among computers on the Internet; a browser lets the user access related topics automatically, and the user does not know that he or she is moving from one computer to another (Lucas, 2000). As technologies become available to individuals, the emergence of the Internet and WWW was a major breakthrough in computer use in education during the early 1990s (Adelsberger, Collis, & Pawlowski, 2002).

Table 2-4: Software for knowledge transfer and conceptual development

IT Issues / Reference	Education system level	ISD phase	Research method
The Internet			
(Foster, 2000)	Higher education	Analyze	Quantitative research (Survey research)
(Montelpare & Williams, 2000)	Higher education	Develop Evaluate	Qualitative research (Focus groups)
(Lazonder, 2001)	Secondary education	Evaluate	Quantitative research (Survey research)
(Mathieu & Schell, 2001)	Higher education	Design Develop Implement Evaluate	Quantitative research (Survey research)
(Zhao & Rop, 2001)	Teacher education	Develop	NA (literary review)
WWW			
(Markellou, Rigou, Sirmakessis, & Tsakalidis, 2000)	Secondary education (Special education)	Design Implement	NA
(Debreceny & Ellis, 2000)	Higher education	Analyze	Quantitative research (Survey research)
(Mitchell, Dipetta, & Kerr, 2001)	Higher education	Implement	Mixed method (Survey research, Case study)
(Schell, 2001)	Higher education	Evaluate	Quantitative research (Survey research)
(Schrum & Hong, 2002)	Higher education	Develop	Mixed method (Qualitative research, Survey research)
(Montilva, Sandia, & Barrios, 2002)	NA	Develop	NA
(Yip, 2002)	Higher education	Develop	Quantitative research (Survey research)
(Cannings & Talley, 2002)	Teacher education	Develop	Qualitative research (Case studies)

The Internet

There are many papers studying the Internet usage (Foster, 2000; Lazonder, 2001; Mathieu & Schell, 2001; Montelpare & Williams, 2000; Zhao & Rop, 2001). Foster explores students' understanding of the Internet as a research tool in a user-based survey. The study shows that students often learn to use the Internet by themselves with little guidance from their educational institution, which may easily result in less effective research strategies. Similarly, Lazonder examines whether and how minimalist instruction may support the development of self-regulatory web searching skills. It is also found that self-regulatory skill instruction did not enhance search performance on the test tasks. The paper of Montelpare and Williams describes the development of undergraduate curriculums using the Internet. Mathieu and Schell also present a course outline where a project-oriented approach is used to teach web-based skills. In addition, Zhao and Rop review the literature on the use of electronic networks for creating reflective teacher communities.

World Wide Web (WWW)

Among the papers discussing the issues of web-based learning (Mitchell et al., 2001; Schell, 2001; Schrum & Hong, 2002; Yip, 2002), Schell conducts a survey to explore students' reasons for choosing a web-based course and their perceptions of course quality and benefit. Yip also reports students' perceptions of a web-based system that assists problem-based learning. Mitchell et al. discuss three approaches of web-based course delivery and recommend the last approach that consolidates and integrates support

for online teaching and learning. Schrum and Hong identify seven dimensions as critical factors that impact the success of adults who enroll in online learning courses, including access to tools, technology experience, learning preferences, study habits and skills, goals or purposes, lifestyle factors, and personal traits and characteristics. Besides, several online teaching strategies, such as students' posting biographies, frequent interaction, collaboration, required participation, question-asking forums, topical flexibility, and minimizing technology requirements, are provided in this paper as well.

Moreover, the paper of Montilva et al. (2002) describes the application of a software engineering approach to the development of instructional web sites. Cannings and Talley (2002) report multimedia and online video case studies enable pre-service teachers to reflect on classroom practice that they might not experience in advance. Targeting people with hearing disabilities, Markellou et al. (2000) introduce a web adaptive educational tool for the Greek Sign Language. In their paper, the system architecture of the tool, its functionality, and the interaction process are presented.

Finally, Debreceny and Ellis (2000) investigate the production of web homepages for Australian universities as a basis to examine institutional attitudes towards the production and management of multimedia. However, it is found in this study that universities are providing a wide range of web services with low levels of staffing.

Applications for communication support

As noted in Table **2-3,** applications for communication support are programs that support communication in different forms, such as word processing software, email tools

and systems, computer conferencing applications, web-boards, chat and MOO tools, and audio and video conferencing applications. According to the papers reviewed, issues of email, chat, and video conferencing are discussed respectively as follows.

Table 2-5: Applications for communication support

IT Issues / Reference	**Education system level**	**ISD phase**	**Research method**
Email			
(White & Cornu, 2002)	Teacher education	Evaluate	Mixed method
Chat			
(Witfelt, Philipsen, & Kaiser, 2002)	Adult education	Evaluate	Qualitative research
Video conferencing			
(Furr & Ragsdale, 2002)	Higher education	Implement Evaluate	Qualitative research (Ethnographic research)

Email

Electronic mail (e-mail) is a system in which computer users have an electronic mailbox and send messages using terminals; communications occur at the convenience of the user (Lucas, 2000). The study of White et al. (2002) shows that e-mail can be used effectively by university teacher educators to facilitate less stressful practicum experiences for student teachers.

Chat

According to Looi (Adelsberger et al., 2002), online chat is a text-based medium by which participants read each other's messages instead of listening to them. Individuals in chat groups can be anonymous. A temporal history of the conversation can be recorded from the text discussion. In addition, an individual's personality can be persistent over different sessions allowing the kind of role differentiation that newsgroups provide. Using the chat function of a conference system, O'Reilly's Webboard (similar to FirstClass), Witfelt et al. (2002) report their experiences using chat as a medium for exams. Using chat as a new way of assessment can help students qualify their study process.

Video Conferencing

Video conferencing refers to a system that uses the personal computer with special hardware and software to code and decode audio and video signals, the Internet, and existing telephone infrastructure. Students can interact with a remote instructor by audio, video, and keyboard in a synchronous environment from their desks or a classroom (Furr & Ragsdale, 2002). Furr and Ragsdale conduct an ethnographic study that examined incidental learning in five desktop video conferencing (DVC) courses offered at an American university. They found that incidental learning often overshadowed the planned curriculum and found a high level of participant frustration. The study's results reaffirm the importance of incidental learning in a DVC course and of developing an environment that avoids or reduces teacher and student frustrations.

Applications for collaborative learning

Applications for collaborative learning include shared workspaces, specially-made systems to support collaborative work, and tools such as workflow. All the communication applications can also be used to support collaboration. In this section, some papers relating to groupware are reviewed.

Table 2-6: Applications for collaborative learning

IT Issue / Reference	Education system level	ISD phase	Research method
Groupware			
(Hogarth, 2001)	Higher education	Evaluate	NA
(Curran, 2002)	Higher education	Develop Evaluate	Quantitative research (Survey Research)
(Komis, Avouris, & Fidas, 2002)	Higher education	Evaluate	Mixed method
(Stacey, 2002)	Higher education	Evaluate	Mixed method
(Lockhorst, Admiraal, Pilot, & Veen, 2002)	Teacher education	Design	Mixed method

Groupware

Groupware is the use of programs on a computer network to facilitate the sharing of information and communications between a group of people who have a common task in a shared environment (Lucas, 2000).

By studying the impact of groupware in the university environment, Hogarth (2001) addresses that introducing groupware technologies into the educational environment may

enhance group working. To ensure groupware success, both business organizations and academic institutions have to understand and manage the social and cultural impacts of introducing group working and groupware technology into the group learning environment. The similar conclusion is also found in the study of Lockhorst et al. (2002). Two student teacher groups are compared to find out how design elements influence the collaborative outcomes. This research reveals that the technical environment is not as important as expected; however, the task instruction and the group process itself have far more impact on the online collaborative work of the student teachers.

Some researchers study the effectiveness of a group learning environment (Curran, 2002; Komis et al., 2002; Lockhorst et al., 2002; Stacey, 2002). Curran introduces Helpmate, an Internet based software application, which creates an online collaboration environment in which users can communicate in real time via a chat room, engage in a video/audio/whiteboard session, communicate in a multi-lingual fashion through real-time translation, see tutor controlled demonstrations on their local PC, view historical data and interact with other students to form a self organizing, self help group. He conducts student surveys and instructor questionnaires to evaluate the effectiveness of the proposed asynchronous collaboration environment as compared to traditional classroom teaching.

In another group learning environment, the Representation 2.0, Komis et al. (2002) collect log files, students' solution and field observation to do the evaluation study. Group synthesis, task control, content of communication, roles of the students and the effect of the tools used are the dimensions to evaluate the use of computer-supported collaborative problem solving environments. Using the similar research approach as

Komis et al., Stacey (2002) found out in the FirstClass conferences that establishing social presence an important aspect for effective online interaction and learning. Other than that, the teacher's role to develop a secure learning environment and model social presence factors and continue to monitor and facilitate conference interaction is a major factor in the success of this interactive process in online learning.

Software for conceptual manipulation

As noted in Table **2-3,** software for conceptual manipulation indicates tools to manipulate representations of concepts in order to come to a deeper understanding of the concept, such as simulations, virtual reality systems, microworlds, concept mapping tools, and workbenches. Among these tools, the most discussed research issue in education is virtual reality (VR). VR is a multi-sensory highly interactive computer based environment, where the user becomes an active participant in a simulated world. It is often used in games, but also in some other area like industry, medicine, e-commerce as well as education (Kameas, Pintelas, Mikropoulos, Katsikis, & Emvalotis, 2000; Lucas, 2000). Research on VR, which includes issues of interface design, student perceptions, cognitive load, and real application environments, suggests that it has become a potential tool for education based on its freedom of navigation and interaction. In addition, other issues about mircoworlds and cognitive tools are also discussed in this following section.

Table 2-7: Software for conceptual manipulation

IT Issues / Reference	Education system level	ISD phase	Research method
Virtual reality (VR)			
(Lapoinmte & Robert, 2000)	Vocational education	Evaluate	Quantitative research (Experimental research)
(Gabrielli, Rogers, & Scaife, 2000)	Primary education	Design	Quantitative research (Experimental research)
(Kaufmann, Schmalstieg, & Wagner, 2000)	Secondary education Higher education	Design Implement Evaluate	Quantitative research (Survey research)
(Whitelock, Romano, Jelfs, & Brna, 2000)	Secondary education Higher education	Evaluate	Quantitative research (Experimental research)
(Diplas & Pintelas, 2000)	Secondary education	Design	NA
(Kameas et al., 2000)	Secondary education	Implement Evaluate	Quantitative research (Survey research)
(Antonietti, Rasi, Imperio, & Sacco, 2000)	Higher education	Analyze	Quantitative research (Survey research)
(Crosier, Cobb, & Wilson, 2000)	Secondary education	Evaluate	Quantitative research (Experimental research)
(Sanchez, Barreiro, & Maojo, 2000)	NA	Design	NA
(Solomonidou & Stavridou, 2001)	Secondary education	Design Develop	Quantitative research (Survey research)
Microworld			
(Johnson, 2000)	Primary education Secondary education	NA	NA
(Dagdilelis & Satratzemi, 2001)	Higher education	Develop	Qualitative research
(Milne & Rowe, 2002)	Higher education	NA	Quantitative research (Survey research)
Cognitive tool			
(Hinostroza, Rehbein, Mellar, & Preston, 2000)	Teacher education	Design Develop Evaluate	NA
(Tselios, Avouris, & Kordaki, 2002)	Secondary education	Design Evaluate	Mixed method

Virtual Reality (VR)

It is found in some papers that VR can support learners developing spatial awareness or abilities (Gabrielli et al., 2000; Kaufmann et al., 2000; Sanchez et al., 2000). Gabrielli et al. examine how different types of exploration of a VR scene by 6 year-old children affect their performance in a series of spatial tasks. Kaufmann et al. develop and apply Construct3D in mathematics and geometry education to assist certain types of problem solving activities.

Lapoinmte and Robert (2000) present a comparative study of the results between the field performance of trainees without VR training and that of trainees who received 25 hours of hands-on training on a forestry machine simulator. The results show that the use of VR training increases by 23% the volume of wood harvested and reduces by 26% the repair and maintenance costs. The use of VR also allows precise recording and monitoring of the evolution of trainees' performance during their training sessions.

There are several studies focused on the design issues of virtual reality environment (Diplas & Pintelas, 2000; Sanchez et al., 2000; Whitelock et al., 2000). Whitelock et al. use several virtual reality environments to investigate how sense of presence may affect the design of virtual environments for conceptual learning. The findings suggest that increasing a user's sense of presence in the virtual reality environment does not necessarily lead to an increase in user's conceptual understanding but impose a possible cognitive overload. Therefore, conceptual tools are required to help the user achieve a deeper understanding of their learning tasks.

Sanchez et al. (2000) provide a framework for the design of VR systems for education that stresses the role of metaphor in teaching and learning. Also, Diplas and Pintelas (2000) describe the Virtual Multi Flow Graph (Virtual-MFG) graphical formal model and the Interaction Specification Workspace (ISW) software architecture for the interaction design of VR educational software (EIKON).

In addition, Kameas et al. (2000) present EIKON to support high school technology courses and evaluate this software by nineteen IT high school teachers in terms of content, pedagogical, and software quality issues. In the subject area of chemistry, Solomonidou and Stavridou (2001) describe the design and development of the software which contains simulations and visualizations of experiments to help students improve their conceptions about chemical equilibrium.

Furthermore, in order to study what students think about the use of VR in instruction, Antonietti et al. (2000) conduct a survey and find that the representation of VR, including motivation and emotion, skills, cognitive styles, benefits and learning outcomes, is not affected by gender, by the previous use of VR software, or by the knowledge of the main topics concerning the introduction of IT in instruction. On the other hand, Crosier et al. (2000) describes the evaluation of VR to teach radioactivity at secondary school level. The results indicate that both ability level and the order in which the conditions are completed significantly affect the attitude scores towards both overall and for the VR class in particular.

Microworld

Computer-based microworlds allow the learner to manipulate a number of variables relevant to a certain domain and thus carry out experiments via the computer which would be time-consuming if possible to do with real equipment (Adelsberger et al., 2002). There are several papers studying the teaching and learning of programming language (Dagdilelis & Satratzemi, 2001; Johnson, 2000; Milne & Rowe, 2002). Johnson indicates that discrete mathematics and algorithms provide a natural "home" for programming. This in turn supports the use of a programming language in mathematical contexts for which pupil designed algorithms can be used to explore concepts and relationships. Dagdilelis and Satratzemi describe how they develop a microworld based on Emil Post's theoretical machine to act as a base for teaching formal programming. The students' dialogues, the programs they wrote on paper or by using the software are used for data analysis. Milne and Rowe conduct a web-based questionnaire whose purpose is to rank programming concepts in order of difficulty, both from the students' points of view and those of their lecturers.

Cognitive tool

Cognitive tools are some kind of software tools that can help the user express his ideas about relationships among variables even if these ideas are original to the learner. Concept mapping tool is one example of this kind of cognitive tool (Adelsberger et al., 2002). Considering the software as an instrument for teachers' professional performance, Hinostroza et al. (2000) present an alternative conceptualization of educational software.

Likewise, based on the concept of student task modeling, the study of Tselios et al. (2002) develops several tools, such as the Cognitive Modeling Tool and the Usability Analyzer Tool, to support design and evaluation of computer-based open problem solving environments.

Educational databases

The applications of educational databases contain hypercard for user-designed and filled databases, multimedia CD-ROMs for large collections of professionally assembled multimedia resources, and web-based course management systems. In order to study the effects that different cognitive styles may exercise on information retrieval strategies, Drenoyianni, Selwood and Riding (2002) use a structured instrument observing and providing records of the students' actions when searching an encyclopedic CD-ROM, Microsoft® Encarta™. The results show that students are extensively lack of information retrieval skills, which disallow wide differences to emerge in terms of searching strategies.

Table **2-8**: Educational databases

IT Issue / Reference	**Education system level**	**ISD phase**	**Research method**
(Drenoyianni, Selwood, & Riding, 2002)	Secondary education	Analyze	Quantitative research (Experimental research)

Tools

According to Table **2-3,** another major IT application in education is that of tools for self-expression and for the self-creation of learning and performance-support materials, such as HTML editors, PowerPoint presentation, search tools and agents. Thus, the papers with respect to multimedia presentations and voice recognition are discussed in the following section.

Table **2-9**: Tools

IT Issues / Reference	**Education system level**	**ISD phase**	**Research method**
Multimedia			
(Lang, 2000)	Teacher education	Develop	Quantitative research (Survey research)
(Van Den Berg & Visscher-Voerman, 2000)	Teacher education	Design Develop Evaluate	Qualitative research
(Passig, 2001)	Early childhood education	Design	Quantitative research (Survey research)
(Gulz, 2002)	Adult education	Design	Qualitative research
(Panselina, Sigalas, & Tzougrai, 2002)	Secondary education	Design Develop Evaluate	NA
Voice recognition			
(Di Petta & Woloshyn, 2001)	Adult education	Implement	Qualitative research

Multimedia

Multimedia is the use of more than one medium in presenting information. For example, the information can be presented with the combination of graphics, video, and audio information (Lucas, 2000).

In some studies, it is important to analyze if a program has different effects on different groups, such as men vs. women, different previous knowledge, different levels of interest, age, intelligence, and aptitude-treatment-interaction (Adelsberger et al., 2002). Some papers focus on different interfaces of multimedia materials and the effect they had on the users (Gulz, 2002; Passig, 2001). Passig finds that boys who are more familiar with computer games show a greater covert time-on-task and higher level of satisfaction than girls. Younger boys and girls are also found to show higher satisfaction than older children. In terms of adult users, Gulz indicates that identifying aspects of individual cognitive variance is particularly relevant for the design of instructional multimedia. Additionally, in the study of Panselina et al. (2002), the design and development of a multimedia system which serves as a bilingual chemistry educational tool for deaf students is presented.

Several approaches are brought up to educate teachers about how to use computers (Lang, 2000; Van Den Berg & Visscher-Voerman, 2000). According to a survey of over 1000 teachers in Germany, Lang indicates teachers are concerned to receive more training in using computers. Therefore, a classroom-based teaching and learning approach in a collaborative network is proposed to upgrade their computer skills. In addition, Van Den Berg and Visscher-Voerman discuss the design and development of

a prototype of a case-based interactive system, delivered via CD-ROM and the WWW, as a means of stimulating collaborative learning in pre-service teacher education.

Voice Recognition

Voice recognition is a technology that can train or teach the computer software to understand and recognize individual speech patterns (Di Petta & Woloshyn, 2001). The study of Di Petta and Woloshyn explores whether voice recognition software could be used to support the delivery of a standardized reading curriculum to adults with low-level literacy skills. Their findings suggest that continuous voice recognition may be useful for fluent readers, but not for those with poor literacy skills. However, the use of voice recognition software in the literacy training curriculum seems to provide the users with a motivational boost, and it is the most effective to have a tutor present to give immediate support to learners.

Information and Communication Technologies (ICT)

Information technology (IT) refers to the combination of computers and communications including all types of computers from desktop workstation to supercomputers and all types of networks; also fax machines, pagers, and communications modes like cable, satellite, and wireless (Lucas, 2000). According to the definition of some researchers (Somekh, 2000; Watson, 2001), the term Information technology (IT) is used interchangeably with the term Information and Communication

Technologies (ICT). ICT is often perceived as a catalyst for changes in teaching style, learning approaches, and access to information (Watson, 2001). Different from the classification listed in Table **2-3**, the technologies discussed in this section combine the web-based integrated resources with non-web systems to one category. Therefore, the papers concerning ICT are included in Table **2-10**.

Table 2-10: ICT

IT Issue / Reference	Education system level	ISD phase	Research method
(Somekh, 2000)	Higher education	Evaluate	NA (Literary review)
(Kapitzke, 2000)	Secondary education	Implement	Qualitative research (Case studies)
(Gough, 2000)	NA	NA	NA (Opinion paper)
(Duvall & Schwartz, 2000)	Higher education	Evaluate	Quantitative research (Survey research)
(Thomas, 2001)	Secondary education	Evaluate	NA (Literary review)
(Nachmias, Mioduser, & Shemla, 2001)	Secondary education	Analyze	Quantitative research (Survey research)
(Tzortzidou & Hassapis, 2001)	Primary education	Evaluate	Quantitative research (Experimental research)
(Watson, 2001)	NA	NA	NA
(Hartviksen, Akselsen, & Eidsvik, 2002)	Adult education	Implement Evaluate	Mixed method (Participatory action research)
(Forgasz, 2002)	Secondary education Teacher education	Analyze	Quantitative research (Survey research)
(MacKinnon & Vibert, 2002)	Higher education	Evaluate	Mixed method
(Dougherty, Kock, Sandas, & Aiken, 2002)	Adult education Higher education	Develop Evaluate	Quantitative research (Survey research)
(Mumtaz, 2002)	Primary education	Analyze	Qualitative research
(Webb, 2002)	Secondary education	Develop Implement Evaluate	NA
(Khalid, Swift, & Cullingford, 2002)	Adult education (Professional ed.)	Evaluate	Mixed method
(Masters & Yelland, 2002)	Primary education	Implement	Qualitative research
(Romeo & Walker, 2002)	Primary education	Implement	Qualitative research
(Knezek & Christensen, 2002)	Primary education Secondary education Teacher education	Evaluate	NA (Literary review)

Among these papers listed above regarding ICT issue in education, Gough (2000) expresses his opinion on clarifying what learning technologies and convergent technologies mean. Somekh (2000) focuses mainly upon the policy and practice in UK schools relating to new technology and learning issues. Kapitzke (2000) proposes that, with appropriate support and guidance, it is feasible for students with technical cultural capital to move from the margins to the center of technological innovation and educational change. In addition, Watson (2001) suggests that pedagogy should be considered before technology.

Some researchers focus on the IT usage and its effect on students' learning (Dougherty et al., 2002; Duvall & Schwartz, 2000; Hartviksen et al., 2002; Khalid et al., 2002; Knezek & Christensen, 2002; MacKinnon & Vibert, 2002; Mumtaz, 2002; Nachmias et al., 2001; Thomas, 2001; Tzortzidou & Hassapis, 2001). Knezek and Christensen summarize a number of findings on the impact of ICT on teacher training and student achievement. Also, Thomas reviews related literature to examine computer use in high school science classrooms and its effects on students' learning.

The study of Duvall and Schwarz (2000) shows there are no significant differences in academic performance between distance learners and their on-campus counterparts and between technology-adept students and those without technological skills. In a 3-year experimental and control study comparing the abilities of perception, information and retrieval and concentration using a text-book and a computer-assisted learning approach respectively, Tzortzidou and Hassapis (2001) suggest that the use of the computer had a positive influence on abilities of perception and information retrieval.

Moreover, Nachmias et al. (2001) conducts a survey to analyze ICT usage by students in an Israeli high school. These results are discussed in the issues of equity, gender, and integration of learning processes taking place within and outside school. Using a qualitative approach, Mumtaz (2002) interviews children to examine their conceptions and understanding of computers. The results show that children with computer access at home and school have a better understanding of the computer system and its functions than their counterparts.

Under a fully wired university setting, MacKinnon and Vibert (2002) explore the use of communication technologies during the case study approaches on their business course. However, not all aspects of technology use are found to be productive in this study. They conclude from their study that the impact of the technology depends heavily on how the instructors integrate the technology into their courses. Focusing on the business sectors, Khalid et al. (2002) use questionnaires and semi-structured interviews to examine the attitudes of secretaries towards the new office technology and its effects on both secretaries and managers in the UK and Malaysia. It is found that, regardless of the size of organizations, both managers and secretaries use new office technology and access almost the same information.

Harviksen et al. (2002) proposes municipal ICT schools as one model for bridging the digital divide between rural and urban communities and provides an assessment of the model based on the results from a field trial in three rural municipalities in Norway. Dougherty et al. (2002) also present their experience designing, developing and conducting a set of case studies using a curriculum development framework, which

incorporates the use of complex, domain-specific IT applications in specific professional fields.

On the other hand, some papers study teachers' IT usage in their teaching (Forgasz, 2002; Knezek & Christensen, 2002; Masters & Yelland, 2002). Forgasz presents his findings with respect to ownership, professional development, perceptions of technological skills, beliefs about the efficacy of computer use in mathematics, and data on how teachers are using computers for teaching secondary mathematics. Masters and Yelland investigate strategies used by a teacher deemed to be exemplary at using computers and associated technology in her classroom. Finally, in the study of Romeo and Walker (2002), they interview the principal, IT coordinator as well as class teachers to determine their views of how Information Communication Technologies in Education (ICTE) was being implemented in their school.

Chapter 3

Results and Analysis

As we can see in the previous discussion, information technology has been widely applied to education. In order to identify IT issues in education, a total of 61 papers are presented and classified in four sets of classifications in the last chapter. In terms of content analysis, Figure 3-1 shows the framework of this paper.

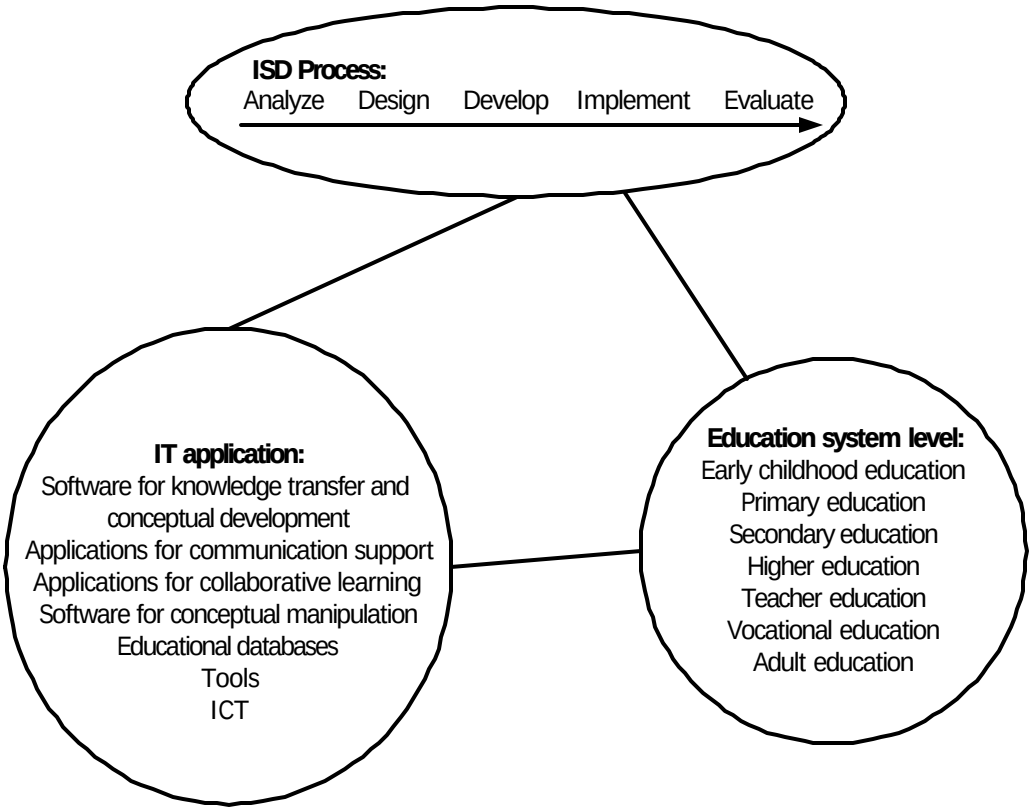

Figure 3-1: A framework for IT issues in education

In addition to IT application, education system level, and the ISD process shown in Figure 3-1, the research methods employed in each paper have also been identified.

Accordingly, this chapter is organized as follows. In the next section, the papers discussing IT issues in education (ITE papers) are classified based on their educational level. The third section provides the results and analysis of ITE papers based on the ISD phase. In the fourth section, the classification of ITE papers is based on their research method. The final section analyzes ITE papers based on their IT application.

ITE papers based on education system level

Basically, each of the 61 articles is classified into one or more education system levels that the researchers target. In some cases, due to general or opinion-oriented research approach employed, papers either cannot be classified or talk about more than one education level. Therefore, it is noteworthy that the total number of papers exceeds 61 and thus the sum of the percentage is not necessarily 100%. The results of the classification are placed in Table **3-1** and illustrated in Figure **3-2**.

Table **3-1**: Classification of ITE papers based on education system level

Education system level	Early childhood education	Primary education	Secondary education	Higher education	Teacher education	Vocational education	Adult education	NA
Software for knowledge transfer and conceptual development	0	0	2	8	2	0	0	1
Applications for communication support	0	0	0	1	1	0	1	0
Applications for collaborative learning	0	0	0	4	1	0	0	0
Software for conceptual manipulation	0	2	8	5	1	1	0	1
Educational databases	0	0	1	0	0	0	0	0
Tools	1	0	1	0	2	0	2	0
ICT	0	5	6	4	2	0	3	2
Total	1	7	18	22	9	1	6	4
Percent	1.6%	11.5%	29.5%	36.1%	14.8%	1.6%	9.8%	6.6%

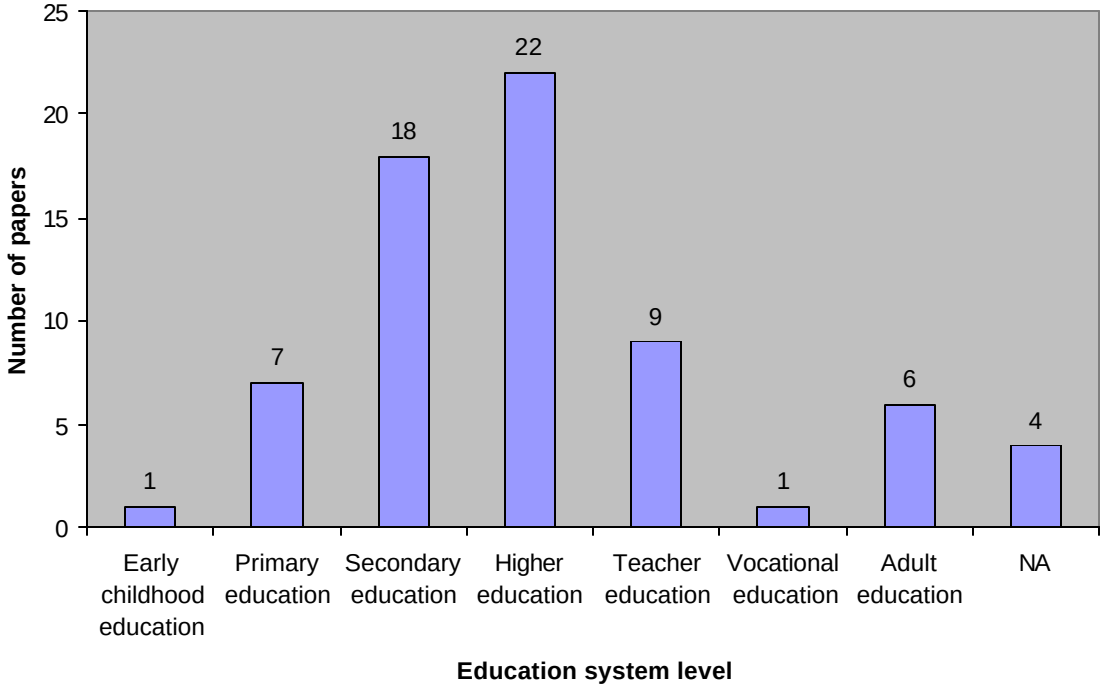

Figure **3-2**: A histogram showing the distribution of papers by education system level

Looking at Table **3-1** and Figure **3-2**, most researchers choose higher education as their research setting over all the other education system levels. Overall, 36.1% or 22 papers are published under higher education institutions. The next most popular researched setting is secondary education. These papers account for 18 or 29.5% of the total articles. Teacher education, primary education and adult education are the next choices within this classification. In terms of number of papers, these three categories include 9, 7, and 6 ITE papers, respectively. There are 4 articles or 6.6% that do not specify any education system level. Moreover, only 1 paper or 1.6% is devoted to early childhood education or vocational education.

Within the post-secondary education category, combined higher education with teacher education, the number of papers accounts for half of all the reviewed papers. This trend might result from some observations. First of all, higher education institutions are generally equipped with the most advanced IT facilities, both hardware and software. In order to provide a competitive environment for teachers and students, there are more budgets or funds in higher education institutions to purchase or upgrade IT facilities. Next, many IT applications are first being promoted and utilized in higher education institutions. College teachers and students are often encouraged or even required to integrate ICT into their teaching and learning. Third, there are more research resources in higher education institutions so that it is easier to conduct research and get research data than other education system levels, no matter the form of numbers or words.

According to the statistics released by the National Center for Education Statistics, students at the high school and undergraduate levels were more likely than elementary school children to use home computers for schoolwork. Judging from the ratio of public school students to instructional computers with Internet access, secondary education level is also higher than primary education level (Kleiner & Farris, 2002). In terms of IT facilities and usage frequencies, primary education is next to secondary education. Therefore, the number of research papers in the primary education categories is less than that in secondary education. On the other hand, it shows that early childhood education and vocational education are the least studied settings in this field. It is not surprising to see the IT research in early childhood education is so scarce. Not only because IT facilities in this level are not as common, but also the usage frequencies among young kids are far less than those of the other education levels. Not to mention

that it is a big challenge to do research on young children. As IT applications become more advanced and widely applied at every education level, it is promising to study IT issues at other education levels like primary education, adult education and vocational education, which have less frequency of research papers in this field.

ITE papers based on ISD phase

In this section, the total number of papers will exceed 61 because each of the 61 articles is classified into one or more ISD phases that the authors examine. In other words, some papers cover more than one ISD phase in their study. As a result, the sum of the percentage in the six categories is not necessarily 100%. Furthermore, given that some papers do not mention the ISD process, the classification into any of the phases would be unavailable in these cases. The results of the classification are presented in Table **3-2** and illustrated in Figure **3-3.**

Table **3-2**: Classification of ITE papers based on ISD phase

ISD phase	Analyze	Design	Develop	Implement	Evaluate	NA
Software for knowledge transfer and conceptual development	2	2	7	3	4	0
Applications for communication support	0	0	0	1	3	0
Applications for collaborative learning	0	1	1	0	4	0
Software for conceptual manipulation	1	7	3	2	7	2
Educational databases	1	0	0	0	0	0
Tools	0	4	3	1	2	0
ICT	3	0	2	5	8	3
Total	7	14	16	12	30	4
Percent	11.5%	23.0%	26.2%	19.7%	49.2%	6.6%

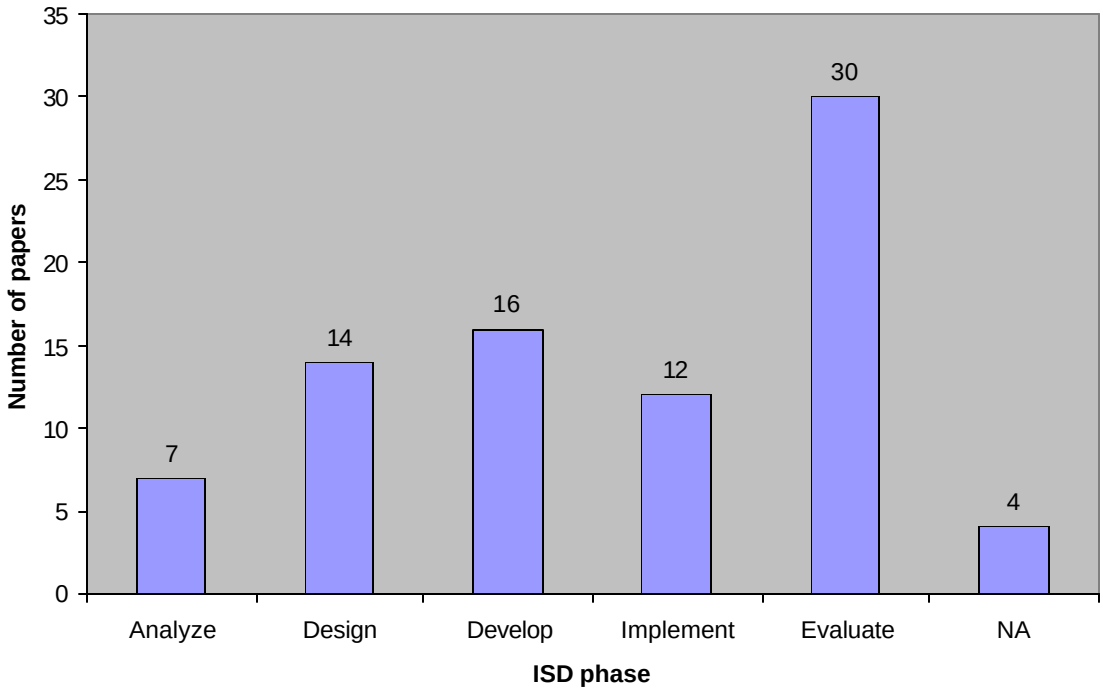

Figure **3-3**: A histogram showing the distribution of papers by ISD phase

As depicted in Figure **3-3**, 30 papers or 49.2% are primarily classified in the evaluation category. The next most examined ISD phase fell in the development category, which accounts for 16 or 26.2% of the total papers. The design and implementation phases are the third and fourth most discussed categories, which account for 23% and 19.7% of the articles, respectively. There are only 7 articles or 11.5% classified into the analysis category. The NA category, which cannot be classified into any of these ISD phases, accounts for 4 or 6.6% of the articles.

As is mentioned in the last chapter, Instructional Systems Design (ISD) is a formalized process for producing learning materials that requires the steps of analysis, design, development, implementation, and evaluation. However, the steps in the ISD process are not discrete activities. It is possible to combine different steps to save the time (Piskurich, Beckschi, Hall, & American Society for Training and Development., 2000).

It is found in this review that a majority of papers (49.2%) study the evaluation phase, the fifth or final phase of ISD. Each evaluation starts with the analysis of goals, conditions, contents, and processes of the program. Instructional evaluation is concerned with understanding, improving and applying methods for assessing the effectiveness and efficiency of teaching and learning activities (Adelsberger, Collis, & Pawlowski, 2002). Therefore, in terms of computer-based learning, the opinions of students, experts, and teachers about their experiences in using the program are valuable for the assessment. Just like Rindermann indicates in his paper:

> Special attributes of modern technologies (e.g. multimedia, hypertext, branching, user-friendly functions) enable a new way of individual and independent learning, and offer researchers new possibilities of evaluation by recording navigation paths, time used, or learning results. (Adelsberger et al., 2002)

Next, the development phase is the second most discussed category of ISD (26.2%). According to Doerksen (Adelsberger et al., 2002), many methodologies can be considered when creating digital learning materials. The development of authoring tools, intelligent systems, adaptive architectures, templates, and other technology solutions has

tried to solve problems relating to programming effort and knowledge. Some researchers (23.0%) are concerned about the design methodologies. Pedagogical design, user-interface design, learning activities design, and different design strategies for a variety of IT applications are the research issues within this category.

In addition, there are still a few papers (19.7%) dealing with the implementation phase. After analyzing, designing, and developing the IT applications for education, some issues about implementation obstacles and solutions are emerging. Rindermann (Adelsberger et al., 2002) also suggests that future work should focus more on the implementation circumstances which contribute to the success or failure of programs.

Among all the ISD phases, the analysis phase seems to be the least examined (11.5%). However, as the basis of the following ISD process, analysis can help determine whether there is a need for instruction, what will be taught, and what behaviors and processes the learner should exhibit. This part of the process is dedicated to the collection of data, which should be used to determine the purpose of the operational system, job or educational situation to be taught. It should be noted that all the analyses such as needs analysis and task analysis are not necessarily completed at a specific time. As a matter of fact, further analysis can always be done later in the ISD process (Piskurich et al., 2000). More papers working on the analysis phase will help identify the learner's needs and specify the learning objectives.

ITE papers based on research method

In this section, each of the 61 papers is classified into a category according to the research method employed by the authors. There are four categories in this regard. In addition to quantitative approach, qualitative approach, and mixed method, the papers that use none of the above research approaches are classified into the NA category. In general, some of these papers in the NA category do literary review on a specific topic; some are theory or opinion oriented papers. The results of the classification are shown in Table **3-3** and illustrated in Figure **3-4**.

Table **3-3**: Classification of ITE papers based on research method

Research method	Quantitative approach	Qualitative approach	Mixed method	NA
Software for knowledge transfer and conceptual development	6	2	2	3
Applications for communication support	0	2	1	0
Applications for collaborative learning	1	0	3	1
Software for conceptual manipulation	9	1	1	4
Educational databases	1	0	0	0
Tools	2	3	0	1
ICT	5	4	3	6
Total	24	12	10	15
Percent	39.3%	19.7%	16.4%	24.6%

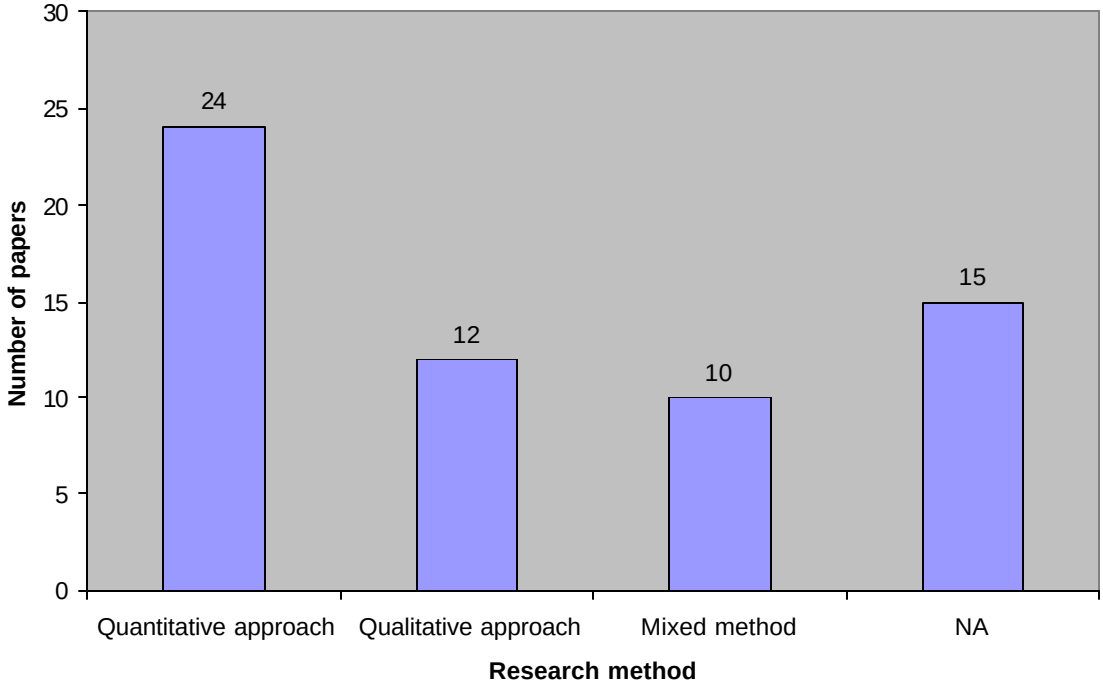

Figure **3-4**: A histogram showing the distribution of papers by research method

The quantitative approach is found to be the dominant research method conducted by ITE researchers. A total of 24 out of 61 papers, or 39.3%, used the quantitative approach to collect their data in the form of numbers. More specifically, most papers in the quantitative approach category use survey or experimental method to do their research. The next category is NA, accounting for 15 or 24.6% of the papers. There are 12 or 19.7% of the papers fall into the qualitative approach category. Furthermore, only 10 or 16.4% of the papers are classified in the mixed method category. The articles in this category use both quantitative and qualitative approaches to collect, analyze and interpret their research data.

In terms of the research methods used, the quantitative approach is quite popular (39.3%). We can also know from the previous section that many papers (49.2%) deal with the evaluation phase. The finding is consistent with the study of Rindermann.

> Normally in evaluation research, more quantitative methods are used. Quantitative data from questionnaires and observation methods, test and objective measurements allow reliable and exact assessments of input characteristics, processes and effects. (Adelsberger et al., 2002)

In this regard, according to Rindermann, the quantitative approach (e.g., survey research, experimental research) is useful for assessing and measuring the effectiveness (are the objectives achieved?) and the efficiency (costs analysis and benefits) of a computer-based learning program.

The next most used research method is the qualitative research (19.7%). Although statistical analysis can examine associations or differences between variables, these results are often lacking clarity and comprehensibility to practitioners. Thus, qualitative methods such as information from open questions, interviews, focus groups, observations and records presented in case studies are more interpretable, but not very representative (Adelsberger et al., 2002). In order to employ the good features of these two methods, a mixed method that combines the quantitative and qualitative approaches is emerging (16.4%). The reasons for combining are to capitalize on the strengths of the two approaches, and to compensate for the weaknesses of each approach; therefore we can increase the scope, depth and power of the research (Punch, 1998).

On the other hand, 15 or 24.6% of the research papers that use none of the above research methods are classified into the NA category. They are usually papers that review literature or present a theory or just express an author's opinion. Mertens (1998) indicates that the review of literature can be seen as an end in itself, either to inform practice or to provide a comprehensive understanding about what is known about a topic. For example, Zhao and Rop (2001) include 28 papers in their review on electronic teacher networks. Then each of these is analyzed according to the criteria established by their five research questions. By means of reviewing several commissioned studies, doctoral dissertations, and projects, Knezek and Christensen (2002) study the impact of new information technologies on teachers and students. Also, Thomas (2001) integrates the findings from recent research with theoretical perspectives from associated education literature, and then proposes guidelines for effective computer use in high school science classrooms. There is an opinion paper such as Gough (2000). Diplas and Pintelas (2000), Markellou et al. (2000), Sanchez et al. (2000) and Montilva et al. (2002) are such papers that present a model or tool for developing IT application for education.

ITE papers based on IT application

Focusing on technologies themselves as the organizing principle for a variety of categorizations adapted from Adelsberger et al. (2002), Table **3-4** and Figure **3-5** show the distribution of ITE papers over the period 2000-2002 published in *Education and Information Technologies*. Each paper is classified according to its IT application type in education. The most discussed IT issue in the education field is found to be ICT, which is

a general term or concept covering all types of computers, networks, and communications modes.

Table **3-4**: Classification of ITE papers based on IT application

IT categories	Software for knowledge transfer and conceptual development	Applications for communication support	Applications for collaborative learning	Software for conceptual manipulation	Educational databases	Tools	ICT
2000	4	0	0	11	0	2	4
2001	5	0	1	2	0	2	4
2002	4	3	4	2	1	2	10
Total	13	3	5	15	1	6	18
Percent	21.3%	4.9%	8.2%	24.6%	1.6%	9.8%	29.5%

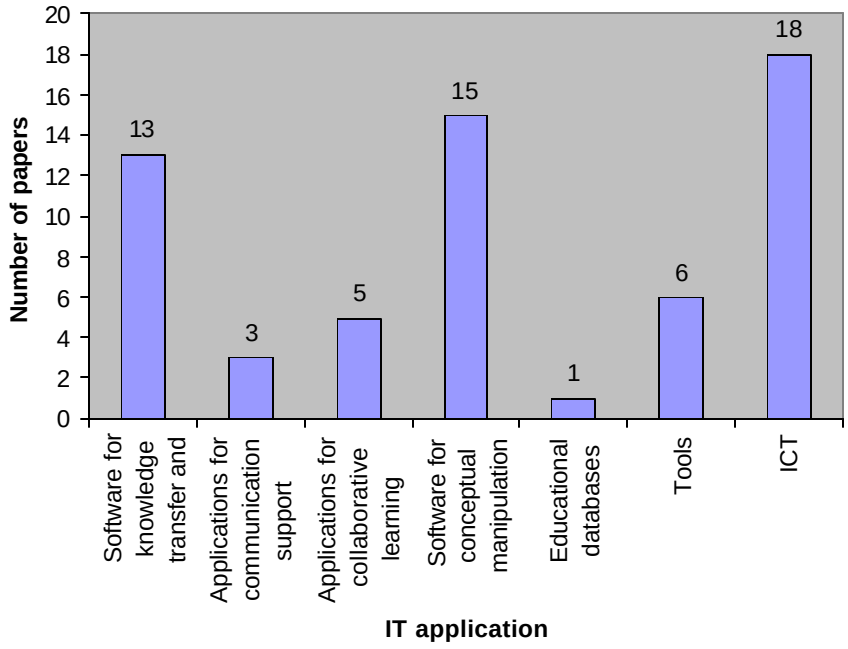

Figure **3-5**: A histogram showing the distribution of papers by IT application

As Table **3-4** shows, the most popular research issue is ICT, which accounts for a total of 18 papers (29.5%). Software for conceptual manipulation is the second most discussed issue of ITE research. There are 15 papers or 24.6% in this category. Software for knowledge transfer and conceptual development is the third most researched issue. About 13 papers, or 21.3%, have studied some topics relating to the Internet or web-based learning. The remaining four categories are research issues with relatively less frequency. They are tools, applications for collaborative learning, applications for communication support, and educational database in sequence by number of papers. In all, only 15 or 24.5% of the papers fall under these four IT categories.

A majority of researchers are interested in IT issues like ICT (29.5%), software for conceptual manipulation (24.6%), and software for knowledge transfer and conceptual development (21.3%). These three IT categories combined account for about three quarters of all the reviewed articles. On the other hand, IT issues such as tools (9.8%), applications for collaborative learning (8.2%), applications for communication support (4.9%), and educational databases (1.6%) are relatively less studied.

Instead of studying more specific IT applications, many papers tend to investigate the IT applications that are more integrated. One reason for this may have something to do with the convergence of information technologies. Adelsberger et al. (2002) indicate that the convergence of mass media communication technologies (radio and television) with telephone technologies and data network technologies is well underway. Another convergence is applications of computer-based tools and applications available within an integrated web environment. For instance, a web-based system can support information handling, presentation support, communication, groupware, course, and learning-specific

resources, all in one integrated environment. In other words, many different sorts of software products can be integrated with web sites. As a result, a lot of papers are devoted to the IT applications that are more integrated, convergent or general. On the other hand, if the specific IT application can be integrated with web sites for the purpose of publication, information dissemination, collaboration, communication, and information and resource handling, then it seems that fewer papers will be classified into this category.

Chapter 4

Conclusions

The objective of this paper is to review the current research issues that information technology presents for education. The literature is classified based on the four different sets of classifications:

1. Educational system levels
2. Instructional Systems Development (ISD) process
3. Research methods
4. IT applications in education

The findings in these classifications are the following:

1. About half of researchers choose higher education and teacher education as their research settings over all the other education levels. Accounting for 36.1% of the total papers, higher education is the most popular researched setting,
2. Papers that examine the evaluation phase of the ISD process account for 49.2% of all articles.
3. The leading research method conducted by ITE researchers is the quantitative approach, which is used by a total of 39.3% of the articles to collect data in the form of numbers. Within the quantitative approach, most papers adopt survey or experimental method to do their research.
4. The information and Communication Technologies (ICT) issue is the theme of 29.5% of the papers.

Like any other literature review that provides a comprehensive understanding about what is known about a topic, there are some limitations of this paper.

1. The limitation of data source

The data source is limited to one academic journal only. It is considered that high quality research papers would be selected in the journal of *Education and Information Technologies,* which publishes papers from all sectors of education on all aspects of information technology and information systems.

2. The limitation of published year

Although this quarterly journal has published over 150 articles since early 1996, the journal articles reviewed in this paper are limited to the published years from 2000 to 2003. Considering the range of issues and the number of papers on education technologies, I focus on the most recent research issues and papers to outline the latest research trend in this field.

The analysis presented in Chapter 3 contributes to the overall understanding of current IT applications in education. The researchers can identify future research topics and needs by viewing the four different classifications of this paper and the numbers of papers published in each category in recent years.

It is found in this study that half of the papers choose post-secondary education as their research setting. However, as IT applications become more advanced and widely applied at every education level, it is promising to study IT issues at other education levels like primary education, adult education and vocational education, which have less frequency of research papers in this field.

With the growth of ITE research papers, current research concentrates mainly on the evaluation phase owing to the recognition and expectation that ICT has pervasive effects or impacts on education. Further research needs to be undertaken to discuss other phases of ISD in order to increase the knowledge about how to best apply IT to education.

In terms of the research methods used, the quantitative approach is more popular than the qualitative approach. However, as Punch (1998) emphasizes, neither approach is always superior to the other. It is a good strategy to consider the purposes and research questions in that the way questions are asked influences what needs to be done to answer them. Combining the two approaches is another alternative that can be done to answer the research questions.

With respect to the IT applications discussed by researchers, much attention is being paid to ICT, software for conceptual manipulation, and software for knowledge transfer and conceptual development. It is inferred that IT applications that are more integrated, convergent or general are the popular research issues. E-learning is one example which integrates many learning technologies into one system. As expected, new technologies will continue to offer innovative IT applications for learning, which will transform the education as well as create more research issues in this field.

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