Promoting the effective use of computers to support the learning and teaching of literacy and numeracy in primary education with attention to pedagogy, teacher reflection and development.

Volume I

by

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Volume I

Brief Contents

Contents

Other references

A list of tables

A list of illustrations

A list of compound variable abbreviations

aanp - the number of pupils in the teaching group or class

ac - Academic Self-concept (in general)

acm - Academic self-concept subscale M: Academic Self-concept in Numeracy work

acr - Academic self-concept subscale R: Academic Self-concept in literacy work

acs - Academic self-concept subscale S: Academic Self-concept in Learning and School work

af_com - teachers' personal attitudes towards computers

af_oac - teachers' perception of effects on pupils' academic achievement resulting from the use of computers

af_owk - the extent of the perceived teaching workload resulting from the use of ICT to support subject teaching

apit - the specification of ICT in teachers' weekly planning

apso - the planning of specific activities to support any computer programs that the teacher use

asad - the adaptation of programs to make ICT suit those with special needs

at_ma - Attitude towards maths (group/class level)

at_re - Attitude towards reading (group/class level)

at_sh - Attitude towards him/herself and school learning (group/class level)

auc - Attitude towards using computers

ccom - the frequency of computer use by the class

chl_f1 - Personal challenges i.e. knowledge & skills about using ICT

chl_f2 - Psychological challenges i.e. personal interest, expectation and concerns

chl_f3 - Institutional and work-related challenges i.e. duties, workload and time available

chl_f3 - the extent of institutional and work-related challenges perceived by the teacher in relation to the classroom usage of ICT

chl_f4 - Practical and resource-related challenges i.e. the need for reliable equipment, technical support and additional supports for pupils

chl_f4 - the extent of the practical challenges perceived by the teacher in relation to the classroom usage of ICT

com - Competence in using computers (self-rated) cperi - the number of hardware/software add-ons on the computers

cu - the frequency of using computers for curriculum purposes

it_psk - the percentage of pupils in class who use a computer at home

it_tsk - teachers' IT skills and knowledge

lcn - Concentration in learning

lma - Learning motive subscale A: Achievement motivation

lmd - Learning motive subscale D: Deep learning motivation

lms - Learning motive subscale S: Surface learning motivation

ls_f - Concrete experience (CE) [teacher-level data]

ls_h - Reflective observation (RO) [teacher-level data]

ls_k - Abstract conceptualization (AC) [teacher-level data]

ls_kf - Abstract-concrete (AC - CE) [teacher-level data]

ls_kft - Abstract and concrete (AC + CE) [teacher-level data]

ls_o - Active experimentation (AE) [teacher-level data]

ls_oh - Active-reflective (AE - RO) [teacher-level data]

ls_oht - Active and reflective (AE + RO) [teacher-level data]

ls_ro - teachers' learning with reflective observation mode of orientation

lsa - Learning styles subscale A: Concrete Experience [pupil-level data]

lsb - Learning styles subscale B: Reflective Observation [pupil-level data]

lsc - Learning styles subscale C: Abstract Conceptualization [pupil-level data]

lsca - Relative position on prehensive dimension of learning (Abstract Conceptualization - Concrete Experience) [pupil-level data]

lsd - Learning styles subscale D: Active Experimentation [pupil-level data]

lsdb - Relative position on transformative dimension of learning (Active Experimentation - Reflective Observation) [pupil-level data]

nt - Value on Software Interactivity

o_zaa - Academic attainment

o_zbk - Home background

o_zma - Maths attainment

o_zpp - Non-verbal ability

o_zpv - Picture vocabulary

o_zre - Reading attainment

o_zsc - Science attainment

o_zwe - Context score

p_coll - teachers' preference for collaborative activities as opposed to individual activities

p_ict - the preference for teaching with ICT as opposed to without ICT

p_ict - the preference for teaching with ICT as opposed to without ICT

p_lang - the preference for teaching literacy as opposed to numeracy

p_open - the preference for teaching with open activities as opposed to closed activities

p_pma - Maths prior value added

p_pre - Reading prior value added

p_psc - Science prior value added

p_pup - teachers' preference for pupil control in learning as opposed to teacher control

p_zpr - Academic prior value added

pcom97 - the opportunity for a typical pupil in class to have a turn on the computer

pr_ff1 - the implementation of teaching practice as a habitual action or routine

pr_ff3 - implementation of teaching practice with critical reflection

pr_ff4 - implementation of teaching practice with premise self-reflection

ptim97 - the amount of time that a typical child spent on the computer during an average week

r_voaa - Academic learning gains (group/class level)

r_voma - Learning gains in maths (group/class level)

r_vore - Learning gains in reading (group/class level)

r_zoaa - Academic learning gains (pupil level)

r_zoma - Learning gains in maths (pupil level)

r_zore - Learning gains in reading (pupil level)

r_zosc - Science learning gains (pupil level)

sc - Social Self-concept

tchl - Challenge variables in general (barriers & supports)

td - teachers' inclination towards the use of ICT in the classroom

tm - Time Management

tp - Teacher-pupil relation (perception of)

zat_ma - Attitude towards maths (pupil level) zat_re - Attitude towards reading (pupil level)

zat_sc - Attitude towards science (pupil level)

zat_sh - Attitude towards him/herself and school learning (pupil level)

Remark: When the variable abbreviation contains "97" or "98", it means that the data of the variable was collect in the academic year 1997/98 or 1998/99, respectively.

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Abstract

This thesis searches for an effective pedagogy with the use of computers or other types of information and communications technology (ICT) from the perspectives of pupil learning and reflective teaching.

It begins with a review of factors that make learning and teaching with ICT effective on the ground of contemporary theories and models of learning and teaching. A model of effective curricular learning and teaching with the use of computers or ICT is proposed. It is used as the framework of investigation throughout the thesis.

The investigation of learning looks at the interaction between computer-specific characteristics and other learning-related characteristics of primary pupils. It also investigates the in-school and out-of-school usage of ICT, subject differences, grouping and gender differences. The investigation of teaching and/or instruction looks at the combination of factors that affect each type of learning outcomes. With consideration into the causal relationships, the results are linked together to form as a path model. The measurement of effectiveness includes learning progress (i.e. educational value-added) and learning attainment of primary pupils, their developed abilities, and their attitude towards learning and towards themselves and school learning.

The results show that the model helps to illuminate the inter-relationships between different components of learning and teaching. In particular, the interrelationships

between teacher characteristics, teacher's practical knowledge, reflection and instructional practice concerning the extent of computer use. It is recommended as a framework for other investigations into effective use of ICT or the development of pedagogy with the use of ICT.

Furthermore, a framework of promoting the use of ICT to support subject-based learning and teaching is proposed. It is examined in four classroom-based research and development projects. The findings show that it is applicable to different subject curriculum, to a spectrum of school-based learning contexts and to different features provided by computers.

Foreward

Warning: If you read all the chapters through at once, you will experience the power of the psychological codes concealed in the thesis to make you sleep!

Suggestion: An effective way of using the thesis is to start with the parts that are of interest or relevant to you. The descriptions below are designed to help you to find the specific sections of the thesis, according to the topics of interest presented as below.

Focus 1: The significance of this study, major findings, implications and suggestions

- An overview of the background and the research needs concerning educational use of ICT and the significance of this thesis.
  ⇨ See Chapter 1 Section 1-3 (Page 14 - 18)
- A summary of major research findings, conclusions and major contributions of this thesis.
  ⇨ See Chapter 7 Section 7-1 (Page 782 - 807)
- Some implications and suggestions.
  ⇨ See Chapter 7 Section 7-2 (Page 808 - 814)

Focus 2: Effective teaching and learning, the use of ICT and the evaluation of performance

- An overview of effective teaching and learning, and the use of value-added information as performance indicators
  ⇨ See Chapter 2 Section 2-1 (Page 21 - 60)
- A review of some contemporary models of effective learning and teaching.
  ⇨ See Chapter 2 Section 2-2 (Page 61 - 92)
- A proposed model of effective curricular learning and teaching supported by computers or ICT.
  ⇨ See Summary of Chapter 2 (Page 119 - 121) See Chapter 2 Section 2-3 (Page 93 - 118)

Focus 3: Pupil characteristics and learning supported by the use of computers

- A review of learning theories and their pedagogical implications, with special attention to the use of ICT to support learning and teaching.

⇨ See Chapter 3 Section 3-1-1 (Page 125 - 140)

- An overview of and an investigation into some computer-specific and learning-related characteristics affecting human-computer interaction, and learning effectiveness.

⇨ See Summary of Chapter 3 (Page 270 - 274)
See Chapter 3 Section 3-1-2 and Section 3-1-5 (Page 141 - 178 and 193 - 232)

- Other factors affecting the effectiveness of learning with ICT, including in-school and out-of-school learning with computers, subject preference, grouping and gender.

⇨ See Chapter 3 Section 3-2-1, Section 3-2-2 and Section 3-2-3. (Page 234 - 238, 239 - 253 and 254 - 269)

Focus 4: Pedagogical and instructional factors affecting the effectiveness of subject teaching and learning supported by ICT

- An overview of and an investigation into some pedagogical and instructional factors affecting the effectiveness of using ICT to support learning and teaching.

⇨ See Chapter 4 Section 4-6-2 'A summary of findings and discussion' (Page 475 - 485)
See Chapter 4 Section 4-2, Section 4-4 and Section 4-5-1. (Page 284 - 361, 367 - 416 and 417 - 441)

- An investigation into the inter-relationships between these factors, including the clarification of causal relationships.

⇨ See Chapter 4 Section 4-5-2 (Page 442 - 459)

Focus 5: The inter-relationships between pedagogy, teacher reflection, teacher learning and development concerning the use of ICT

- An overview of and an empirical investigation into conceptions of reflection, with special attention to the factor structure of an instrument for assessing teacher reflection developed on the basis of transformative learning theory. ⇨ 📖 See Chapter 5 Section 5-1-1 (Page 491 - 543)

- The results of an exploratory factor analysis to identify aspects of pedagogical preferences. ⇨ 📖 See Chapter 5 Section 5-1-2-2 (Page 549 - 552)

- The results of a hierarchical cluster analysis to identify the nature and the structure of the challenges posed by the use of ICT. ⇨ 📖 See Chapter 5 Section 5-2-2 (Page 600 - 604)

- A path model explaining the development of pedagogy supported by the use of ICT. ⇨ 📖 See Chapter 5 Section 5-2-5 (Page 631 - 649)

- A summary of the results of research studies addressing the inter-relationships between educational effectiveness, pedagogy, teacher reflection, teacher learning and development concerning the use of ICT. ⇨ 📖 See Summary of Chapter 5 (Page 650 - 656)

Focus 6: Supporting effective teaching and learning with the use of ICT: Some case studies of school-based research and development work

- A framework for supporting primary teachers and pupils for effective classroom-based learning through the use of ICT. ⇨ 📖 See Chapter 6 Section 6-1, Section 6-6 and Summary of Chapter 6 (Page 659 - 667, 757 - 777 and 778 - 779)

- Research and development project 1: Using spreadsheets on portable computers to develop mental calculation skills through prediction of number patterns in Year 4.

⇨ See Chapter 6 Section 6-2 (Page 668 - 681)

- Research and development project 2: Improving reading and spelling for low achievers and children with special educational needs in Years 4 to 6 using a text-to-speech support facility on the computer.

⇨ See Chapter 6 Section 6-3 (Page 682 - 700)

- Research and development project 3: Using two multimedia software applications to foster the reading development and the understanding of science topics in Year 6.

⇨ See Chapter 6 Section 6-4 (Page 701 - 727)

- Research and development project 4: Using computers for in-class and out-of-class learning in Year 3.

⇨ See Chapter 6 Section 6-5 (Page 728 - 756)

Chapter 1

Introduction: An outline of this thesis

The aims of this chapter are to:

- provide an outline of the scope of this thesis,
- introduce the methods of study and presentation, and
- justify the significance of this thesis.

- A list of the sections in Chapter 1 -

- End of the list -

(1-1) The scope and organisation of this thesis

What is this thesis about?

This thesis investigates the effective use of computers to support the learning and teaching of literacy and numeracy in primary education. Attention is paid to the learner's characteristics, pedagogy, teacher reflection, teacher learning and development as well as to the classroom practices of teachers, pupils and external developers who want to promote the use of computers for subject-based learning.

The thesis begins with an introduction chapter (Chapter 1), which provides an outline of the scope of this thesis, the methods of study, the organisation of the content, the background and the significance of the work. This is followed by (Chapter 2) a review of literature about the use of value-added measures (or "evidence-based" data) as performance indicators and about theoretical models of effective teaching and learning. A model of effective curricular teaching and learning supported by computers is proposed as the framework of investigation throughout the thesis (i.e. Illustration I2-2K).

The investigation of learning (Chapter 3) supported by computers is carried out after a review of some contemporary learning theories relevant to the use of ICT. It addresses learning from the perspective of human-computer interaction. Some other factors affecting the effectiveness of learning with ICT are considered. These include in-school and out-of-school usage of ICT, subject differences, grouping and gender. The investigation of teaching and/or instruction (Chapter 4) supported by computers is carried out on the basis of a literature review of some selected issues. The results provide an updated picture of current classroom practices and the information about recent trends/movements in pedagogical and instructional practice with the use of ICT in primary classrooms in the UK. Potential factors affecting each type of learning outcome measure and possible causal relationships between these factors are explored. This is followed by an extended investigation (Chapter 5) into pedagogy, teachers' reflective thinking, learning and development and the challenges encountered as a result of using computers. The results demonstrate the interrelationships between teacher characteristics, practical knowledge and instructional practice as well as giving support to the model proposed in Chapter 2.

Furthermore, a framework for promoting the use of ICT to support learning and teaching of literacy and numeracy is proposed (Chapter 6). The results of and the experience gained from four classroom-based research and development projects examine its appropriateness. These projects address various aspects of the primary curriculum, different features provided by computers and a spectrum of learning and instructional contexts. The findings and inferences made in the previous chapters are supported and a refined framework for promoting the use of ICT to support subject teaching and learning in primary school is proposed. Preliminary findings also show that it has great potential to be used as a framework for promoting the use of ICT for out-of-school learning. Finally, the final chapter (Chapter 7) provides a summary of the major contributions of the thesis, identifies some implications and gives suggestions for classroom practice and future research and development work in learning and teaching supported by computers.

The focuses of investigation above are inter-related. The investigation of effective curricular teaching and learning supported by computers is informed by several theoretical models or frameworks of investigation in this thesis, including the framework for an investigation into learning in Chapter 3 (i.e. Illustration I3-1B), the framework for an investigation into some pedagogical and instructional factors affecting the effectiveness of educational use of ICT in Chapter 4 (i.e. Section 4-3 and Section 4-6) and the framework for an investigation into the development of a pedagogy supported by ICT through teachers' reflective thinking and practice in Chapter 5 (i.e. Illustration I5-2D and I5-2E).

In this thesis, the challenge of creating an effective learning environment supported by ICT is regarded as a complex problem. The seek for a technical solution, such as finding variables associated with effective learning or effective teaching alone, is not good enough to equip teachers or instructional designers to tackle the challenge. The effectiveness of learning and teaching supported by the use of ICT is affected by the combination of a range of learning and instructional variables associated with a specific learning context. Therefore, teachers and instructional designers need to make adjustments between the theoretical and practical aspects of their own pedagogy according to the characteristics of the instructional environment. Reflective teaching is promoted in this thesis because it provides the strength for making changes in pedagogy and it is an interface for teacher learning and development.

The model of effective curricular teaching and learning supported by computers is built around three major parties: the teacher, pupils and the computer/ICT. The learning activities in the model often take place as the interaction between them (i.e.

Illustration I2-2L). When applying the framework to support primary teachers and pupils for effective classroom-based learning through the use of ICT, the interaction between the teacher, the pupils and the external developer becomes the focus of investigation in Chapter 6 (i.e. Illustration I6-1A). An external developer is the person responsible for promoting and supporting pupils and teachers in the use of computers/ICT for effective learning and teaching. When applying the framework to support the use of ICT for out-of-school learning, the focus of investigation is the interaction between the parent(s), the pupil and the external developer(s) (i.e. Illustration I6-2A).

Before moving on to the next section, it is worthwhile to draw attention to some concepts that will frequently occur in the thesis. The purpose of this is to keep readers away from conceptual confusion. They are listed as below:

Effectiveness

In this thesis an operational definition of effectiveness has been adapted. Effectiveness is assessed by pupils' learning attainment, learning progress, attitude toward literacy and numeracy, toward themselves and their school learning. Their verbal and non-verbal abilities are also taken into consideration. The data is mainly based on the value-added data provided by the Curriculum, Evaluation and Management Centre (CEM) at the University of Durham. It is one of the world's largest monitoring centres in education and the work of the centre is at the forefront of education research in evidence-based education (Cohen et. al., 2000). Besides this, effectiveness is also evaluated by data obtained from the administration of some other tests (e.g. standardised reading and maths), interviews and questionnaires (e.g. closed/open-ended). Further description about effective teaching and learning is available in Chapter 2.

Computers and/or ICT

The computer is the major and the most common type of information and communications technology (ICT). However, there are also other types of ICT. In this thesis, other types of ICT include calculators, video cameras, digital cameras, electronic keyboards, fax machines, spell-checkers, turtles and roamers. The reason for using both terms in the thesis is that the term "ICT" was used in some of the instruments when they were administered. For example, both terms were used in the teacher survey in 1997/98 when it was administered by the team at University of Durham, in collaboration with the team at University of Newcastle upon Tyne.

However, the present thesis does not deal much with other forms of ICT. Readers should bear in mind that whenever a generalisation about ICT is made in the thesis, it applies primarily to the computer. In this thesis, the usage of computers is focused on teaching and learning. Other types of computer usage, such as using computers for school administration or the teacher's record keeping, are not within the scope of this thesis. Nevertheless, both computers and ICT are tools for learning and teaching purposes. They are different from information technology (IT), which is a subject in the school curriculum.

Pedagogy and/or instruction

In continental Europe, the term "pedagogy" began to exist in the seventeenth century. In the nineteenth century, with the work of Pestalozzi and Herbart, pedagogy was regarded as a science of teaching. There were concerns about theory because education was a subject of enquiry and study.

In contrast, Simon (1999) claims that there is no pedagogy in England. In the last century, pedagogy was neglected mainly because teaching practice was dominated by laissez-faire pragmatism. There was no concern about theory and education was viewed as an eclectic subject. In classrooms nowadays, pedagogy is equivalent to craft knowledge and skill in teaching. With the belief that teachers need practical knowledge and skills about the learning and teaching context, pedagogy is often regarded as an art of teaching. From this perspective, it would not be possible or appropriate to rigidly pre-specify the role of a teacher and then apply it in every situation.

The discussion above suggests that there are two major views toward pedagogy. This thesis tries to combine them together as two aspects of pedagogy, including the theoretical aspect and the practical aspect of pedagogy. It is assumed that the two aspects of pedagogy are inter-related. The idea is consistent with Leach & Moon (1999) and McCormick & Scrimshaw (2000), who think that pedagogy comprises several inter-related dimensions:

"educational goals and purposes;

a view of learning;

a view of knowledge;

the learning and assessment activities required;

the roles and relationship between learners and between the teacher and the learner;

the classroom discourse

(McCormick & Scrimshaw, 2000; Leach & Moon, 1999)."

It might be worthwhile to note that teacher learning and development are often bi-directional. Teachers learn from the application of learnt knowledge and existing views of instruction as well as by shaping up a style or a pattern of consistency in teaching and instruction. In other words, the development of pedagogy includes the craft and skills in teaching practice as well as the formulation and refinement of the teacher's knowledge and existing views of instruction. To maximise the effectiveness of learning and teaching in the U.K., the author of this thesis thinks that efforts have to be paid to both aspects of pedagogy.

To individual teachers, the theoretical aspect of pedagogy is often represented as a form of belief or existing views about teaching and instruction. In other words, in classroom practice, many teachers nowadays are guided by some theories of learning and instruction. For example, Kamphaus et. al. (1990) provide an outline of the contribution of instructional psychology in education. They think that theories of development, learning and instruction have helped to identify effective teacher behaviour during instruction and to find variables that maximise student achievement.

More importantly, instructional psychology also has influenced the application of computer technology to learning and instruction. It is obvious that the term "instruction" occurs more frequently than the term "pedagogy" in literature concerning the use of computers or ICT for learning and teaching purposes. Computer-based instruction, computer-assisted instruction and instructional design are common terms in this field. This gives the support for using the term "instruction", as well as the term "pedagogy", in this thesis.

In relation to the scope of pedagogy defined by McCormick & Scrimshaw (2000), the concept of instruction is covered by pedagogy. Instruction has more to do with cognitive domain and the major focus is on learning outcome. In contrast, pedagogy includes a whole range of theories and practices, including personal characteristics, knowledge about the subject and the curriculum, motivation, teacher behaviour, instructional design, provision, allocation and functionality of equipment, assessment,...etc. Readers are advised to bear in mind that whenever the term instruction is used in this thesis, it refers to a part of pedagogy.

(1-2) Methods of study

How are the topics in this thesis being investigated?

The topics in this thesis are investigated at two levels. At teacher/class level, a range of data collection methods is used. These include observation, questionnaire, open-ended questions, interviews and the use of value-added data. The collected data are used to investigate the effectiveness of teaching/instructional variables, pedagogy, reflection and teacher development. A list of the data collected at teacher/class level is presented in Table T1-1.

Table T1-1: A list of data collected at teacher/class level

Instrument/Method of data collection (focus of evaluation)	Nature of data (size of data collection)	Reference (initiation of data collection)
Observation (lessons with and without the use of ICT)	Qualitative and quantitative (a total of 113 lessons)	Appendix 1-A^ and Appendix 1-B^
Questionnaire (survey of using ICT)	Mainly quantitative data with qualitative comments (250 and 64 respondents)	Appendix 2-A in 1997/98^^ and Appendix 2-B in 1998/99^
Questionnaire (pedagogical preference)	Quantitative data (24 and 51 respondents, making a total of 75)	Appendix 2G collected in 1997/98^ and in 1998/99*
Follow up questionnaire (tendency to use ICT, curriculum use of ICT, teacher's IT skills)	Quantitative data (top up the size of data collection above to 74 or 85 respondents)	Appendix 2-D*
Extended questionnaire (teacher reflection, teacher's learning style, workload, challenges concerning the use of ICT)	Quantitative data (range from 73 to 117 respondents)	Appendix 2-C**, Appendix 2-D**, Appendix 2-E** and Appendix 2-F**
Questionnaire and phone contact (matching database of this thesis with value-added data in PIPS)	Quantitative data (ranged from 29 to 145 successfully matched respondents)	Appendix 2-E** and Appendix 2-F**
Interviews (use of ICT, classroom practice, teacher reflection)	Qualitative data (about 60 interviews)	Collected in 1997/98^ and in 1998/99^
Open-ended questionnaire (framework of promoting the use of ICT for in-school & out-of school learning)	Qualitative data (26 respondents)	Appendix 2-C**, Appendix 2-D** and Appendix 2-F**

Remark: The author wants to give special thanks to the team at Centre of Curriculum Evaluation and Management (CEM) in Durham University for their generosity in providing value-added data and their assistance in processing the data. The author also wants to give thanks to the TTAICT project team at Newcastle upon Tyne and the Teacher Training Agency (TTA) for their generosity in providing their project database.

Keys: ^ refers to the data collection and the items of the instrument which were initiated and designed by the TTAICT project team at Newcastle upon Tyne, while the author of this thesis was involved as a full-time research staff and a project member. ^^ refers to the data collection and the items of the instrument which were initiated by the TTAICT project team at Newcastle upon Tyne and designed by the TTAICT project team at Durham (i.e. CEM centre in University of Durham) and at Newcastle upon Tyne while the author of this thesis was involved as a full-time research staff and a project member. * refers to the data collection which was initiated by the author with items specially designed for this thesis and items designed by the TTAICT project team. ** refers to the data collection which was initiated by the author with items specially designed for this thesis.

At pupil level, the data collection methods include pupil questionnaire, parents' questionnaire, the administration of standardised tests, logbook, the use of video clips and computer files on the computer, and the use of value-added data. The collected data are used to investigate the interaction between human and the computer, and its implication to teaching and instruction. Other issues concerning pupil learning with the use of computers are considered. These include subject difference in learning preference, in-school/out-of usage of computer, gender difference, and pupil's social status in learning activities with/without the use of computers. A list of the data collected at pupil level is presented in Table T1-2.

Table T1-2: A list of data collected at pupil level

Instrument/Method of data collection (focus of evaluation)	Nature of data (size of data collection)	Reference (initiation of data collection)
Pupil questionnaire (human-computer interaction)	Qualitative and quantitative (a total of 252 pupils)	Appendix 3-A**
Pupil questionnaire (subject difference in learning preference, in-school/out-of usage of computer, gender difference)	Qualitative and quantitative (a total of 166 pupils)	Appendix 3-B**
Pupil questionnaire (social status in learning activities with/without the use of computers)	Qualitative and quantitative (a total of 229 pupils)	Appendix 3-C**
Value-added data in PIPS (matched with data collected from the instruments above)	Quantitative data (a total of 112 pupils, but the number of successfully matched cases varies)	Refer to Chapter 2 section 2-1*

Standardised maths, reading & spelling tests (evaluation of pupil's attainment/progress)	Quantitative data (available for all the 4 classes selected as case studies, about 20 to 30 pupils in each class)	Refer to Chapter 6 section 6-2^, section 6-3**, section 6-4** and section 6-5^
Video clips and computer files recorded on the computer (observing/recording activities on the computer)	Mainly qualitative data (available from all the 18 pupils reported in Chapter 6 section 6-3)	Refer to Chapter 6 section 6-3** and Appendix 5-A**
Pupil questionnaire (open-ended questions concerning software and group work with the use of computers)	Qualitative data (available from the 31 pupils reported in Chapter 6 section 6-4)	Chapter 6 section 6-4** and Appendix 6-C**
Pupil questionnaire (interactivity, cognitive, affective and emotional outcomes of two computer software applications)	Quantitative data (available from the 31 pupils reported in Chapter 6 section 6-4)	Chapter 6 section 6-4** and Appendix 6-D**
Pupil questionnaire (surveys of pupils' confidence in using computers)	Quantitative data (available from the 30 pupils reported in Chapter 6 section 6-5)	Chapter 6 section 6-5**, Appendix 7-F** and Appendix 7-G**
Pupil logbook (record of time spend on in-school & out-of-school activities with & without the use of computers)	Quantitative data (available from the 27 pupils reported in Chapter 6 section 6-5)	Chapter 6 section 6-5** and Appendix 7-H**
Parent's questionnaire (record of time spend on in-school & out-of-school activities with & without the use of computers)	Mainly qualitative data, with quantitative data. (available from the 27 pupils reported in Chapter 6 section 6-5)	Chapter 6 section 6-5** and Appendix 7-J**

Remark: The author wants to give special thanks to the team at Centre of Curriculum Evaluation and Management (CEM) in Durham University for their generosity in providing value-added data and their assistance in processing the data. The author also wants to give thanks to the TTAICT project team at Newcastle upon Tyne and the Teacher Training Agency (TTA) for their generosity in providing their project database.

Keys: ^ refers to the data collection and the items of the instrument which were initiated and designed by the TTAICT project team at Newcastle upon Tyne, while the author of this thesis was involved as a full-time research staff and a project member. * refers to the data collection which was initiated by the author and was provided by the CEM centre in Durham University. ** refers to the data collection which was initiated by the author with items specially designed for this thesis.

The collected data in both levels include qualitative and quantitative data. Further details about the data analysis and the issues to be addressed will be discussed in the respective chapters and sections of the thesis. Furthermore, four case studies were carried out to investigate the implementation of learning and teaching supported by computers or ICT in primary classrooms. Data collected at teacher/class level and at pupil level were used. The experience gain and the qualitative results from the case studies will be used to validate a model of "promoting learning and teaching supported by the use of computers and other ICT" proposed in the thesis.

(1-3) Background and significance of this thesis

Why are these issues important in education?

"

Information technology (IT) is rapidly changing the world we live in, and having a profound effect on the nature of society and employment and consequently on the requirements placed on schools and colleges. The literate and effective citizen of the future we need new skills...In time IT will change the education system itself. The demand for education will continue to increase but the way in which people learn will change and teaching styles will need to adapt.

(NCE, 1995, page 1)"

The statement made by the National Commission on Education (NCE) indicates the potential that ICT can bring to education. It is worthwhile to note that simply using computers and/or ICT is not sufficient for bringing desirable educational outcomes.

Recent overview classroom teaching and learning practice (e.g. McFarlane et. al., 2000; Schacter, 1999; Kulik, 1994) have suggested there are advantages and disadvantages in using computers and/or ICT and the results imply that computers have to be used in appropriate ways so as to be effective. This suggests the importance of preparing teachers for the use of ICT, other than providing and maintaining high-performance ICT equipment. Nevertheless, government statistics show that there has been a rapid improvement in the provision of ICT equipment in primary schools in UK during the last five years (i.e. refer to Appendix 4).

Since 1998, the Department of Education and Skills (DfES) has required all courses of Initial Teacher Training (ITT) to equip trainee with reasonable ICT skills, knowledge and understanding of when, when not and how to use ICT effectively in teaching specific subjects in the primary curriculum. The ITT national curriculum for the use of information and communication technology in subject teaching asks trainee to take account of the functions of ICT (TTA, 1998). Poole (1998) has expanded the functions as the descriptions below:

"

1. speed and automatic functions: monitoring, controlling and feedback,
2. capacity and range: richness of resources, the power of communications,
3. provisionality: ease of amending the outputs,
4. interactivity: dynamic feedback and immediate response to changing inputs.

(Poole, 1998, page 20)"

For the trainees or the practising teachers, the process of making decision of "when the use of ICT is beneficial to achieve teaching objectives in the subject and phase" and "when the use of ICT would be less effective or inappropriate" (TTA, 1998) not only requires them to make use of the functions of ICT in subject teaching, but also integrate and construct their own knowledge and skills concerning the use of ICT with and upon their existing pedagogy. As with other kinds of curriculum material, the trainees and/or the teachers need to know how to adapt and interpret the computer and/or ICT resources to fit their own philosophy of education. The change to be involved often goes beyond the scope of instruction, and can lead to changes in the teacher's pedagogy. This gives the reason why Scrimshaw (1997) regards the computer as a "catalyst for radical educational change" because "it helps us to pursue our current conceptions of education more effectively than we could do with traditional kinds of resource". The interaction between pedagogy and technology can be bi-directional. Salomon and Perkins (1996) state, "technology is more than just the means of making a pedagogical dream come true; often the dream is influenced by what the technology affords, thus leading to the modification of the rationale." The need to search for a pedagogy that is supported by and/or integrated with the use of ICT is obvious.

McCormick and Scimshaw (2000) have expressed their frustration about the neglect of teacher learning and development aspects of recent work on pedagogy with the use of ICT. They point out, "recent attempts to characterise pedagogy in relation to the use of ICT in the UK have gone some way to illustrating an analysis and subsequent development work grounded in theory (e.g. Moseley, Higgins and others, 1999). Such attempts have not in our view explored pedagogy in terms of contemporary views of learning and knowledge. Nor have they related to teachers' knowledge in a way that reflects these views or the more complex methods of such knowledge now available. The exploration of teacher knowledge is necessary to indicate the way teachers need to change, which has implications for any implementation strategies."

Having participated as a member of the TTAICT project team, the author of this thesis believed that the collected information could be analysed further with the use of multiple regression analysis technique in a structured way. The results could make contributions to illustrate the inter-relationships between various pedagogical issues related to the use of computers and pupil learning outcome. Unfortunately, the search of pedagogy supported by the use of computers and the issue of teacher development were not addressed properly, as identified by McCormick and Scimshaw (2000). This justifies doing extended analysis with existing teacher level (or teaching group / class level) data of the TTAICT project and adding to the database some other relevant teacher variables addressed in this thesis. Furthermore, the author also initiated the collection of additional data at pupil level, providing useful evidence in the search for effective pedagogy concerning the use of computers and other types of ICT. He also expected that reflection, from the perspective of teacher training and development, would have an important part to play in preparing teachers for the use of computers or ICT.

In the search for effective pedagogy supported by computers or ICT, the author of this thesis believes that the following areas of work are needed:

- An exploration of pedagogy on the basis of a review of contemporary theories of learning and knowledge and some research work on pupil learning with and/or without the use of computers or ICT.
- An investigation into pedagogical and instructional variables that are found to be effective in affecting pupil learning achievement and/or learning progress.
- An analysis of teachers' pedagogical preferences and perceived challenges concerning the use of computers or ICT for subject teaching and learning from the perspective of teacher reflection, teacher learning and development.
- An attempt to link the issues above together to form as a coherent model or framework of effective curricular learning and teaching supported by computers or ICT.
- Some classroom-based case studies to examine the validity of the model or framework above, with attention to learning and teaching.

This work would lead to practical suggestions and recommendations for promoting the use of computers or ICT for effective subject learning and teaching. However, it is not an easy task to complete the research agenda. There are difficulties, challenges and obstacles. For examples, the amount of ICT-related resources available to primary education is insufficient. Children in primary education require time to develop their IT skills and a high level of support to facilitate their learning with ICT. Teachers also need support to help them adapt to the changes in pedagogy. Work on teacher training would likely include conceptual and practical changes of teachers. Extra time and resources are needed for teachers to try out new ideas concerning the use of ICT.

Chapter 2

Effective teaching and learning, the use of ICT and the evaluation of performance

The major aims of this section are to:

- introduce effective teaching and learning, value-added and measures of learning outcome in this thesis.
- provide a review of literature of some theoretical models concerning effective teaching and learning and some models concerning the educational use of computers.
- formulate a model of effective curricular teaching and learning supported by computers and used it as the framework of investigation in the other chapters of this thesis.

- A list of the sections in Chapter 2 -

- End of the list -

(2-1) Effective teaching and learning: The use of value-added information as performance indicators

(2-1-1) The effectiveness of teaching and learning

Over the last three decades, there has been growing interest in the effectiveness of education, leading to investigations into the key factors affecting school effectiveness. Thanks to the researchers in school effectiveness, a knowledge database has been established and is still expanding. For instance, there are research findings showing how effective schools differ from ineffective schools. Having said that, it is important to have a clear view about the meaning of "effective" before going any further about the associated characteristics.

The Oxford Advanced Learner's Dictionary of Current English (1962) has defined effective as "having an effect" and "able to bring about the result intended". The Longman Dictionary of Contemporary English (1988) has defined effective as "having a noticeable or desired effect" and "producing the desired result". In combining them together, the meaning of "effective teaching and learning" in this thesis includes the two aspects below:

- the pupils have a noticeable or desirable change, and
- the pupils achieve the intended learning target(s).

The first aspect considers effectiveness in terms of the "improvement" "progress" or "learning gain" made by the learner, while the second aspect considers effectiveness in terms of the "achievement" or "attainment" in subject content. Clearly the two aspects are closely interrelated and both of them are essential in this thesis. Having said that, it might be worthwhile to note that the term "effective" or "effectiveness" is often defined in a vague way. It may contain one or both of the two concepts above. It may be determined by the judgement made by professional colleagues, by outside bodies or some other ways. Its scope and definition vary between different researchers.

(2-1-2) Performance indicator: The importance of value-added in education

The importance of "progress" and "attainment" for making judgement

There has been growing concern about the importance of educational effectiveness during the last three decades. It was clear that a lot of emphasis was placed on the standard of the schools while relatively little emphasis was placed on the noticeable or desirable change that pupils made out of schooling. Schools were classified as "good" schools if their pupils had high academic achievements or attainment, and vice versa. However, as a result of ineffective teaching and learning, a good reader could make a slow progress in reading. On the contrary, a poor reader could make a rapid progress in reading as a result of effective teaching and learning. So, there is a need to consider both aspects of effectiveness.

Value-added in education

During the last three decades, there has been an increasing interest in looking at educational "progress" from a "value-added" perspective. The term "value-added" is derived from economics. It refers to the difference between inputs and final outputs represented by the value of sales. For example, if we buy a lemon for twenty pence, turn it into lemonade and sell it for fifty pence, we can say that the added value is thirty pence. The formidable value-added tax will also be based on its added value. Similarly, education is a process that brings an increase in the value of human resource for society. It can be regarded as a process of equipping pupils with knowledge, attitudes, skills or qualifications that lead to better employment opportunities. Therefore, value-added in education can be interpreted as the learners' changes, as a result of education. In this thesis, it is used as a tool to show pupils' relative position or relative progress as a consequence of school teaching and learning.

When looking back to the history of value-added in education, it was first introduced about thirty years ago. During the 1970s and 1980s, the idea was regarded as something theoretically sensible, but difficult to carry out in practice. Thanks to the initiatives by researchers, academics and people from the private sector, its importance became popular during the last ten years. All this hard work facilitated the initiative of setting up a National Value Added system by the government in 1998.

Background leading to the value-added system in the UK

Education and training has a crucial role for the economic, political, and cultural development of a society. Governments around the world take the responsibility of providing for their people better opportunities to learn. Like many European countries, the UK has achieved well in the first step toward the mission by introducing compulsory education. As another step forward, attention has to be paid to the quality, equity and standard of education.

With the explicit aim of promoting market operation mechanism in education, the 1988 Education Reform Act intended to prepare parents to make informed choices and to increase the concerns of school accountability (see Mortimore et al., 1994, p.327). The idea is to get better value for public expenditure. Since school teaching and learning have been legally required to work on the National Curriculum, which is common to schools around the country, comparisons on performance of schools are facilitated. From the late 1980s onwards, there were debates about how to measure school performance. There were two focuses of concern. Firstly, school inspection done by Her Majesty Inspectorate (HMI), which included the Office of Standards in Education (OFSTED) in 1992. Secondly, league tables based on pupil "raw" results in public examinations, began to be introduced as a tool for making the comparisons public.

An OFSTED inspection aims to assure the quality of education provided, the educational standard achieved, the spiritual, moral, social and cultural development of pupils at school and the management of the school's financial resources. Their inspection framework is operated through a list of criterion-referenced indicators on the checklists. There are concerns and criticisms about the reliability of observational techniques and the appropriateness of these indicators to show the quality of teaching. The aim about school management was also criticised as focusing upon the efficiency of the school, while the major focus should be placed on the effectiveness of schooling. There are alignments and discrepancies between OFSTED's framework and research findings about school effectiveness. The author of this thesis queried whether these variables mainly deal with the education processes. For example, school administration is one of the intermediate variables that may and may not have direct impact on a specific educational outcome. In contrast, a direct measure of the educational product is fundamental to account for the impact of schooling.

League tables were based on quantified measures of educational outcomes in standardised key stage tests or public examinations. Perhaps the first official league table by the Government was the one published in the Parent's Charter in 1992 (refer to Foxman, 1997). It became an annual publication of A-level results of schools and institutions at matriculation level. Since then, performance tables for secondary schools also started to be published by The Guardian and The Times Educational Supplement in 1996. Since March 1997, the publication also includes Key stage 2 test results of primary schools. Although publication of raw results of the schools seemed to be informative, researchers, academics and people in education sector keep pointing out that the information could be misleading when the differences in input are not taken into account. The major issue is that only part of the difference between school results is attributed to the school. League tables based on raw results are actually using contaminated indicators to show the effects made by schooling. It might be fairer or more appropriate if assessment took into account the increment on performance of each individual child that is under the control of the school. Having said that, we should note that even the best measuring techniques have limitations on technical grounds.

With all this background, 1992 seems to be an important landmark for the development of a value-added system in education. Firstly, in relation to advancement in statistical methods for educational assessment, the concept of value-added becomes commonly recognised. In particular, the call for value-added measures of school performance is proposed by the National Commission on Education (McPherson, 1992). In calculating school performance, special attention has to be paid to the contributions schools make to pupils' progress. Secondly, apart from academics and statisticians, the Secretary of State for Education by then had considered the use of a value-added measure, although a decision was made to stick with "raw" results.

Having said that, the search for fairer and more valid ways of comparing school performance in context and indicating educational standard and quality did not end. A great leap forward began in 1995 when the Secretary of State for Education and Employment made a contract for the National Value Added project by the Curriculum, Evaluation and Management centre (CEM) in Durham. The final report of the piloted national system in the project was published in 1997, with findings and suggestions about the feasibility, design and implementation of a national value-added system. It was the beginning of a new era when value added measures were put in the National agenda. According to the schedule reported by Saunders (1998), the first National Value-added analyses, covering KS1-2, KS2-3 and KS3-4 was published in the autumn term of 1998. Secondary school performance tables will include value-added measures by 2000 and primary school performance tables will include them by 2002.

Value-added measures and their link with school effectiveness research

School effectiveness research has concentrated on investigating the differences in achievement between schools. Since teaching and learning are the major practices of schooling, value-added studies of teaching and learning are key topics of school effectiveness research (see Teddlie & Reynolds, 2000; Creemers, 1994; OECD, 1995). These research studies have been quite successful in helping to identify factors that are connected with "effectiveness" and in understanding the mechanisms by which schools have their effects. The research findings provide the basis for judgement about accountability of schools.

For thirty years school effectiveness researchers have been interested in the progress made by pupils. Instead of using the "raw" results at the time when pupils leave the schools, school effectiveness research takes account of pupils' level of performance on entry and the level of performance when they leave. The metaphor has close alignment with the approach of value-added measurements in education, which takes account of non-school factors that contribute to pupils' achievement (Saunders, 1998). School effectiveness research uses data collected on a retrospective basis, but value-added measures do not end at this point. They are useful to predict pupils' future performance and make a contribution to school improvement. Value-added measures obtained on a regular basis are useful tools for monitoring education. In relation to this, Coe and Fitz-Gibbon (1998) say that school effectiveness research is "limited by the omission of longitudinal data and has often been characterised by unsupported assumptions about the homogeneity of school effects".

To summarise, value-added analysis is often used as a measurement tool about how effective the school is in promoting pupil achievement. Besides that, longitudinal value-added analyses nowadays are also used as tools for educational management. Having said that, the major focus of this thesis is on the effectiveness of teaching and learning rather than on the effectiveness of the school. The paragraph below will explain the difference between them from a multilevel perspective.

School effectiveness in a multilevel perspective

The knowledge database of school effectiveness research done during the last three decades is very useful for school improvements. According to the National Commissioner of Education, there are a number of ways in which it can help schools and colleges to be more effective. It can:

"

- motivate students
- improve the quality of teaching and the quality of learning;
- help teachers to be more productive;
- help schools and colleges to manage themselves and the learning process more effectively.

(NCE, 1995, page 1, summary)"

The improvement suggestions above lead to further analysis of the effectiveness of schools. In detail, three major levels were identified from school effectiveness research. These include:

- effectiveness at school level,
- effectiveness at teacher level (also called "teaching" or "instruction" level), and
- effectiveness at pupil level (also called "learning" level).

Pupils are the key persons responsible for their own learning outcomes. The work of the teachers and the influence of the schools can be classified as various means of facilitating learning. However, there is no guarantee that learning will follow - no matter how well the teachers or the schools have performed. The best they can do is to increase the probability that learning will take place, by improving the environment in which learning take place.

Half a century ago, academic achievement was the major criterion for making educational judgements. For a fair judgement, researchers in school effectiveness keep suggesting that the "progress" factor needs to be considered. A pupil's learning can be classified as "effective" if his or her progress is higher than it might be expected in comparison with other pupils with similar intake characteristics. A teacher's work (teaching) can classified as "effective" if the progress of his or her pupils in the teaching group is higher than it might be expected for pupils with similar intake characteristics. A school can be classified as "effective" if the progress of its pupils is higher than might be expected for pupils with similar intake characteristics.

So, effective teachers or effective schools add extra value to the pupils' outcomes in comparison with other teachers or schools serving similar pupils. By contrast, having an ineffective teacher or an ineffective school, the pupils make less progress than other pupils with similar intake characteristics.

(2-1-3) Performance indicators in this study

The need for good indicators of educational performance

"A performance indicator can be defined as an item of information collected on repeated occasions to check on the performance of a system.... should be recognised as agreed ways of measuring the extent to which agreed goals are being achieved" (Fitz-Gibbon, 1991).

Fitz-Gibbon, 1991 suggests 12 criteria of good performance indicators. To be brief, they are listed as below:

"

1. Indicators refer to the outcomes of managed units
2. Indicators relate to outcomes which staff can reasonably be expected to influence
3. The major outcome indicators are contextualized
4. Indicators are fed back to the units of management – and they get back
5. Indicators are perceived to be fair
6. Indicators are accessible
7. Indicators are explained
8. Indicators are incorruptible
9. Indicators are checkable
10. Indicators are perceptibly improve if the unit improves its performance over time.
11. Behavioural implications of the indicators are beneficial
12. Costs are reasonable

(Fitz-Gibbon, 1991, page 11-17)"

More importantly, she evaluated the use of residuals from simple regression, relative ratings in standard tables, national comparison factors in standard tables, residuals based on multilevel modelling, percentage pass rates and teacher-given assessments as performance indicators. In the calculation of value-added, the results of linear regression technique was found to be very close to the results of multilevel modelling (Fitz-Gibbon, 1997).

The danger of contaminated performance indicators

To compare the academic performance between pupils in different schools, we can either use their raw results (e.g. school league tables) or value-added measures as the indicator. Foxman (1997) has reported about the effects of league tables based on pupils' results. In relation to teaching and learning processes in primary schools, the effects that he stated include:

- staff who are teaching effectively in schools which are low in the league tables may be depressed in morale because their intake has low attainment,
- schools could be more inclined to exclude disruptive pupils than they were formerly to avoid or to reduce their effect on the learning of a large proportion of a class,
- the possibility of targeting pupils at the level 3 / 4 interface, and
- the possibility of focus more on the core curriculum of English, Maths and Science at the expense of other National Curriculum subjects

(adapted from Foxman, 1997).

To conclude, the use of pupils' raw academic results as the indicators of educational performance may be associated with some negative impacts to the quality of education. In contrast, Tsui (1996) suggested that the aim of education had to be focused on developing the potential of individuals. On the basis of this, learning tasks have to be set at a challenging but attainable level. Instead of focusing on the level of academic attainment, the assessment system of educational performance could focus on pupils' performance in the learning targets set for them, with higher expectations for above-average achievers. So, it is in line with the rationale of a value-added approach of assessing educational performance.

Calculation of value-added

There are different ways of calculating value-added. Here are some brief descriptions about them.

1. Simple subtraction, using the equation:

   Value added = Output measure – Input measure

   Fitz-Gibbon (1996) gives a clear description about this and its use. As an example, if a pupil had two attempts in the GCSE examination, we might be able to use the number of subjects passed in the first attempt as the input variable and the number of subject passed in the second attempt as the output variable. The value added is the difference in the number of passes between these two attempts. The use of this method is restricted to the consistency of measurements. Fitz-Gibbon suggests that it can be used only if both the output measure and the input measure are assessed in the same way. The computed value-added measure can be defined as the "progress made" by pupils.

2. Ordinary least squares method, using the equation:

Value-added = Actual output score – Statistically predicted score

Like the output measure above, the actual output score is an indicator of pupils' current achievement. To work out the value-added, a linear regression line has to be constructed to show the general pattern of relation between pupils' actual output scores and the input(s) scores, when the whole national dataset that year has been taken into account. The predicted score is a specific score on the linear regression line. It is the best-estimated score that a pupil would have obtained if he or she had made average progress or attainment, based on the trend of the whole sample population. The linear regression line is constructed as a best fit line with the criteria of taking the smallest sum of squared differences between the actual output scores and input scores. This statistical criterion is also known as ordinary least squares method in statistics.

When the difference between the actual output score and the statistically predicted score is worked out, it is called "residual" in statistics. This is also known as the value-added in education. It tells us if the performance of individual pupil is relatively better or worse than reasonably predicted with the help of statistical techniques. The computed value-added measure can be defined as a pupil's "relative progress or relative performance". There are two major sub-types of linear regression model contributing to the calculation of value-added. These include:

a. Simple regression model

The statistical predicted score is estimated by a model where one set of input scores is used as the predictor for the output scores.

b. Multiple regression model

The statistical predicted score is estimated by a model where more than one set of input scores are used as predictors for the output scores.

3. Multilevel modelling

This is a sophisticated statistical technique, which explains data in a hierarchical structure. Data are collected from different levels, such as combinations of the level of the pupil, classroom, department, school and LEA. The technique is useful to account for the extent of contribution made by each level of education input in a statistical model simultaneously.

Simple regression model is used in this thesis as a report of a preliminary study

When commenting on the use of value-added measures in the second Education Digest (1992), an anonymous author states that multilevel modelling technique is the "most difficult to understand for non-statistical reader" and "it may be that the use of multilevel analysis is not the best place to start". On the contrary, the SCAA working party (SCAA, 1994) stated that there is strong evidence for "using simple methods of analysis alongside complex ones".

In the Final report of the National Value Added Project, Fitz-Gibbon (1997) reported that correlation between the results of readily understandable residual analysis model and indicators of more complex models was high. She also mentions that school value added indicators would hardly be altered by the use of the more complex computations. Since either approach could be used, simple methods could be recommended. Fitz-Gibbon (1998) also reports that "given correlations of 0.9 between residuals based on multilevel models and ordinary least squares (OLS) regression, it seems likely that the simple 'readily understandable' OLS methods can be used for initial feedback". It might be worthwhile to note that school effectiveness researches often process data at pupil level and at school level, while data at teaching group level (i.e. teacher level or classroom level) are neglected. In the final report of the Value Added National Project, Fitz-Gibbon stated, "The school is not the correct second level in the multi-level modelling. It is the teaching group that delivers instructions and should be modelled. Information on teaching groups would not be acceptable as part of a national system,...(Fitz-Gibbon, 1997, p.106)"

After considering these issues, it became easy to make the decision to use simple regression in this study. Firstly, this study is a preliminary investigative study of the relation between issues about supporting teaching and learning with ICT and the associated value-added. The relative importance of factors at different levels is definitely not the focus. Secondly, the extent of expected difference between results by simple regression analysis and those by complicated multilevel analysis is small.

Performance indicators in this study

Together with data of some other variables of interest, the value-added data to be used in this thesis are provided by the Performance Indicators in Primary Schools (PIPS) project. It started 5 years ago with 12 schools and was originally based at University of Newcastle upon Tyne. Along with the A-level Information System (ALIS) project team, the Year 11 Information System (YELLIS) project team, Middle Years Information System (MIDYIS) project team, the PIPS project team is now based at the Curriculum Evaluation and Management Centre (CEM) of Durham University. The present PIPS project database was collected from around 4000 schools in the academic year 1996/97, 1997/98 and 1998/99, respectively. In each cohort year groups, an independent database is formed with assessment data of about 45,000 pupils. Pupils' value-added in maths and reading (Year reception, 2, 3, 4, 5 and 6) as well as science (Year 6 only) are the primary interest in this thesis. Information of other variables, such as the picture vocabulary test results (PV), the non-verbal problems of position (POP) test results, the attitude measures of the above subjects, the self-concept and attitude toward school learning measure will also be used to extend the investigation. The raw data were kindly made available by the PIPS project team. There are also variables newly generated by the author for the specific purposes in this thesis on the basis of the original value-added data. A complete list of the outcome variables can be found in Table T2-1-1 to Table T2-1-5 below.

Generally speaking, two types of value-added data are provided by the PIPS project. This is a summary of the descriptions in a recent newsletter of the project (refer to PIPS, 1999b):

1. Longitudinal value-added data

The PIPS project describes the data as "prior value-added measures". It uses individual pupils' attainment in previous assessments to predict their present level of attainment. PIPS (1999b) states that it tells us something about the pupil's progress since the last PIPS assessment. It is a useful indicator of the relative progress made by the pupil, however, it tells us little about whether we can expect them to do better still.

2. Cross sectional value-added data

The PIPS project describes the data as "concurrent value-added measures". It is a snapshot of where the pupil is in relation to a combination of his or her verbal ability, non-verbal ability and home background at the time of measurement. It uses individual pupils' "context" score to predict the present level of attainment. The context score is a composite index formulated by the composition of "picture vocabulary", "problems of position" and "cultural capital" measures, with the weighting of 50%, 40% and 10%, respectively. As the context score is obtained through curriculum free tests, it serves as a reliable control for the prediction. It tells us if a pupil is doing as well, better or worse than expected at the time of measurement. Unlike prior value-added measure, concurrent value-added measure is not the type of value-added in the sense of pupil progress. Instead, the indicator can provide a fair comparison of schools, classes or teachers in relation to the ability or basic skills of pupils. In other words, it tells us the extent of success in using the pupil's potential in academic tasks when compared with a similar pupil.

In this thesis, only cross-sectional data are used because:

- longitudinal data are not available from many of the schools/teachers involved in this study, and
- the relationship between the two types of data are reasonably close.

It was reported that the two types of measure are positively related to one another. The size of association is about 0.7 (PIPS, 1999b). To justify the second point above, a technical study of calculating value-added and other learning outcome is performed. The study is presented in section 2-1-4. It is hoped that the study will help readers to develop a better understanding of the outcome measures in this study.

The multilevel nature of the data is also considered in the thesis. Teaching group level (i.e. also named as "teacher" level or "classroom" level) investigation is based on aggregated results of individual pupils within the teaching group. Pupil level investigation extends the investigation of effectiveness in relation to various aspects of individual differences e.g. gender, learning styles and prior attainment. None of the investigations in this thesis is carried out with the use of data at school level.

Performance of education concerns both standard and quality. In line with this, the present study uses pupil attainment scores and value-added scores. It is hoped that they can give information about how well teaching and learning took place. As these measures of learning outcome are "relative" measures, the learning outcome of a pupil can be compared to those of his/her peers.

As the "quality of education" has close links with the aim of education, its definition is multi-dimensional in nature. Apart from being exhaustive, it is hoped that indicators in this thesis are illustrative to show the quality of education. The effectiveness of bringing changes to the pupil is a useful indicator on the quality of education. The effectiveness is based on evidence of educational outcome, which differs from variables of educational efficiency - such as school management issues. It is possible for a school with a lower attainment score to be shown to be more effective in bringing changes in pupils than a school with a substantially higher attainment score. In line with this, the implementation of a national value added assessment system seem to be encouraging for setting "challenging but realistic targets" in daily schooling practice.

Measures of value-added and other types of learning outcome

The outcome variables of this thesis were based on data collected from the PIPS project at University of Durham and data collected from some standardized tests of attainment and progress. The two sections below provide some descriptions of them.

There were five sub-types of data collected on the basis of the PIPS project. The descriptions of each of the variables can be found in the tables below.

(2-1-3A) Outcome variables based on scores in tests of academic attainment

Table T2-1-1: Descriptions of variables concerning academic attainments

	Var. Name	Var. Abbrev.	Description of the variable (from PIPS 1998/99 dataset)
A1-1	Maths attainment	o_zma	The pupil's maths score in PIPS tests, expressed in T-scores
A1-2	Reading attainment	o_zre	The pupil's reading score in PIPS tests, expressed in T-scores
A1-3	*Academic attainment*	*o_zaa*	*The average of "u_o_zma" and "u_o_zre" above*
A1-4	Science attainment	o_zsc	The pupil's science score in PIPS tests, expressed in T-scores

Remark: The data are kindly provided by the CEM centre in Durham University. Variables printed in italics refers to variables newly generated by the author on the basis of the provided data. T-score is a standardised score with a mean of 50 and a standard deviation of 10 (i.e. T-score = 50 + 10 z-score).

(2-1-3B) Outcome variables based on current value-added (or "learning gains")

Table T2-1-2: Descriptions of variables concerning value-added (or "learning gains")

	Var. Name	Var. Abbrev.	Description of the variable (from PIPS 1998/99 dataset)
A2-1	Learning gains in maths	r_zoma	To calculate the current value-added data in PIPS, each pupil's context score was used to predict pupils' maths scores. The prediction was made by simple linear regression technique, on the basis of the information all the pupils in that year group in PIPS. This variable was the maths residual score, which indicated how well was the pupil's maths performance when compared with the expected performance (or predicted performance) at the time of the test.
A2-2	Learning gains in reading	r_zore	To calculate the current value-added data in PIPS, each pupil's context score was used to predict pupils' reading scores. The prediction was made by simple linear regression technique, on the basis of the information all the pupils in that year group in PIPS. This variable was

			the reading residual score, which indicated how well was the pupil's reading performance when compared with the expected performance (or predicted performance) at the time of the test.
A2-3	*Academic learning gains*	*r_zoaa*	*The average of "r_zma" and "r_zre" above*
A2-4	Science learning gains	r_zosc	To calculate the current value-added data in PIPS, each pupil's context score was used to predict pupils' science scores. The prediction was made by simple linear regression technique, on the basis of the information all the pupils in that year group in PIPS. This variable was the science residual score, which indicated how well was the pupil's science performance when compared with the expected performance (or predicted performance) at the time of the test.

Remark: The data are kindly provided by the CEM centre in Durham University. Variables printed in italics refers to variables newly generated by the author on the basis of the provided data.

(2-1-3C) Outcome variables based on scores in developed ability and cultural capital (i.e. cognitive ability and home background)

Table T2-1-3: Descriptions of variables concerning developed ability and cultural capital

	Var. Name	**Var. Abbrev.**	**Description of the variable** (from PIPS 1998/99 dataset)
A3-1	Non-verbal ability	o_zpp	The pupil's problems of position score in PIPS tests, expressed in T-scores
A3-2	Picture vocabulary	o_zpv	The pupil's picture vocabulary score in PIPS tests, expressed in T-scores
A3-3	Context score	o_zwe	The pupil's context score in PIPS tests, expressed in T-scores. This is a composite variable formulated by the following weightings: .5 * (o_zpv) + .4 * (o_zpp) + o_zbk
A3-4	*Home background*	*o_zbk*	*The pupil's home background score in PIPS tests, expressed in T-scores*

Remark: The data are kindly provided by the CEM centre in Durham University. Variables printed in italics refers to variables newly generated by the author on the basis of the provided data. T-score is a standardised score with a mean of 50 and a standard deviation of 10 (i.e. T-score = 50 + 10 z-score).

(2-1-3D) Outcome variables based on various attitude measures

Table T2-1-4: Descriptions of variables concerning attitudes towards subject learning, towards oneself and towards school learning

	Var. Name	Var. Abbrev.	**Description of the variable** (from PIPS 1998/99 dataset)
A4-1	*Attitude towards maths*	*zat_ma*	*The pupil's score about the attitudes towards maths in PIPS tests*
A4-2	*Attitude towards reading*	*zat_re*	*The pupil's score about the attitudes towards reading in PIPS tests*
A4-3	*Attitude towards him/herself and school learning*	*zat_sh*	*The pupil's score about the attitudes towards himself/herself and school learning in PIPS tests*
A4-4	*Attitude towards science*	*zat_sc*	*The pupil's score about the attitudes towards himself/herself and school learning in PIPS tests*

Remark: The data are kindly provided by the CEM centre in Durham University. Variables printed in italics refers to variables newly generated by the author on the basis of the provided data.

(2-1-3E) Outcome variables based on prior value-added data in PIPS

Table T2-1-5: Descriptions of variables concerning prior value-added

	Var. Name	Var. Abbrev.	**Description of the variable** (from PIPS 1998/99 dataset)
A5-1	Maths prior value added	p_pma	The pupil's maths prior value added in PIPS
A5-2	Reading prior value added	p_pre	The pupil's reading prior value added in PIPS
A5-3	Academic prior value added	p_zpr	The pupil's prior combined maths and reading score in PIPS
A5-4	Science prior value added	p_psc	The pupil's science prior value added in PIPS

Remark: The data are kindly provided by the CEM centre in Durham University. Variables printed in italics refers to variables newly generated by the author on the basis of the provided data.

Note that variables in section 2-1-3A, section 2-1-3B, section 2-1-3C and section 2-1-3E above are measures represented in standardised scores. T-score is a standardised measure with scores falling between 0 and 100 and the mean score is 50. All the standardisation procedures were carried out at pupil level. The exception is variables in section 2-1-3D, the standardisation procedure was performed at class/teaching group level on the basis of the raw data provided by the PIPS project team in CEM centre. Later, the attitude measures of year 4 are reversed so as to be consistent with the attitude measures of year 2. The attitude measures of year 6 are dropped because the measurement scale is incompatible with that of those in the combined database.

Except in section 2-1-4 of this Chapter, prior value-added was not used in this thesis. The main reason for that was the lack of longitudinal data from many pupils/schools involved in this study. Instead, the thesis will rely on cross-sectional data.

(2-1-3F) Data from standardised reading tests and maths tests

Beside data originated from the PIPS project, the thesis also collected data from the administration of several standardised tests published by Hodder and Stoughton. They were also used in the four case studies of the thesis. These include:

- Basic Number Screening Test (BNS) by Bill Gillham and Kenneth Hesse,
- Group Mathematics Test (GMT) by D. Young,
- Reading Progress Test (RPT) by Denis Vincent, Mary Crumpler and Mike de la Mare, and
- Parallel Spelling Test (PST) by Dennis Young.

In two of the case studies (i.e. section 6-2 and section 6-5 of Chapter 6), the data collected from the administration of the standardised tests were used as a part of the TTAICT project and as a part of this thesis. In the other two case studies, the data collected from the administration of the tests were only used for this thesis. Nevertheless, the computer worksheets used as informal assessments in the second case study were originated from the book "Phonological Awareness Training" written by Jo Wilson.

It might be worthwhile to note that the tests (i.e. except GMT) have provided a useful measure of the pupils' attainment age. The information could be used as a rule of thumb in comparing the academic achievement or progress made by pupils. For example a reading age of 8 for a 7-year child would imply a higher than average attainment, and a progress of 2 months in spelling age in 3 chronological months would imply a lower than expected learning gain. Therefore, like PIPS data, the information available from these tests contain achievement and value-added data.

Justifications for using measures in maths and reading

Having said that, only attainment and attitude measures of maths and reading were used in this thesis. Since a value-added measuring system is rather complicated, it was thought better to start with simple measurements. At present, indicators in the cognitive domain seem to be the most readily accessible and recognised comparative measures. Reading and maths are fundamental subjects for all the pupils in primary schools. As requirements of national literacy and numeracy initiatives, the two subjects occupied more than half of pupils' time in school. Therefore, value-added in maths and reading are used in this study as primary reference-points, with the hope that indicators about other areas will be developed in the coming future.

On the other hand, measuring techniques about value-added in other domains are relatively crude. For example, it is difficult to measure pupils' development of self-esteem and their attitude towards life. Although it seems obvious that society needs measures of various aspects of teaching and learning performance, as mentioned above, a set of objective, reliable and valid indicators is not available. Therefore, value-added measures in this study are confined to the academic attainment in maths and reading. It is advisable to extend the measures to areas such as politeness, cleanliness, services, physical abilities (e.g. eye-sight tests, chest expansion volume, running speed), social abilities, citizenship (e.g. civic education), self-discipline and artistic skills (e.g. pupils' performance in inter-school contests and competitions in music, sports, swimming, speech, drama...etc).

To conclude, the author of this thesis supports the rationale of "whole-person education". Besides pupils' academic achievement, a good performance measuring system should also include affective and psychomotor domains in Bloom's taxonomy (Bloom et. al., 1964). More widely, it has to cover "moral, intellectual, physical, social and aesthetic" development of individuals promoted by traditional Chinese culture.

The use of league tables has to be carefully considered. The comparison and dissemination of information about schools' performance should be fair. Besides looking at the educational outputs, characteristics of schools and educational inputs have to be taken into account. For example, HKEC (1996) has suggested that an ideal performance indicators should cover pupils':

- academic results
- participation in extra-curricula activities
- interpersonal skills
- citizenship
- ethos, conduct and morality

- punctuality
- dropout rate
- suicidal rate
- crime rate

The PIPS data are collected in an "evidence-based" approach. They are provided by the CEM centre in Durham University. The centre is believed to be the one of the largest centres for monitoring the curriculum (Cohen, 2000). The PIPS tests give all the participating pupils an equal opportunity to achieve well no matter which schools, classes or areas they come from. Therefore, it is reasonable to use the assessment results as performance indicators that give comparative information between pupils and between teachers.

The contribution of value-added measures in teaching and learning evaluation

When compared with league tables that show pupils' attainment in terms of raw results, a value-added system seem to be more appropriate and fairer to show pupils' attainment and progress in learning because:

- Effectiveness of teaching and learning become clearer when factors that are not related to the teaching and learning processes have been taken into account. For example, pupils' ability and home background.
- Value-added measures are more than a comparison of the effectiveness of different schools or teachers, they also enable us to track and predict the progress of individual pupils.

- Value-added data are high quality data. They measure the progress of individual pupils when compared with the progress made by similar others. Therefore, comparison is made on a "like with like" basis.
- Value-added data provide the means to evaluate and monitor curriculum learning
- Feedback about value-added analyses could be useful for internal evaluation and development purposes for schools and teachers
- Although this thesis argues against its use as a public accountability system, well handled value-added information seems to be a better indicator about quality and effectiveness of teaching and learning than raw results. If league tables about school performance are used in public, value-added information alongside with raw results will reduce bias in reporting and interpretation.
- Instead, the author of this thesis thinks that pupils' progress, represented by the difference between outcome and input measures, seems to be a better indicator. Value-added measuring techniques enable adjustments for input factors to be made.

Value-added analyses can provide useful information for:

- parents in making choices about schools,
- for teachers and schools as a mean of self-evaluation,
- schools to develop their plan of future work, and
- educational authority agents (e.g. DfEE, LEA) to make schools accountable for their work.

In this study, the purpose and the use of value-added measures are restricted to internal evaluation and development of the schools and the teachers. Unlike formal assessment of educational performance (e.g. SATs), the use of data reduces the pressure and/or the temptation to cheat and increases the motivation for teachers and schools to participate. Special attention is paid to the "alterable" classroom variables, such as motivation, groupings, attendance, ...etc. Issues about its use as a public accountability system have already been reasonably well addressed in the Value-added National Project. Therefore, the use for public accountability (e.g. league table) is not considered in this thesis in order to avoid going too far from its fundamental interest of how teachers teach and how pupils learn.

(2-1-4) A technical study on the calculation of value-added measures in this thesis

(2-1-4A) What is this study about?

Background

So far research findings consistently report that pupil academic achievement can best be predicted by their prior achievement (e.g. Saunders, 1999). Alternatively, in the Value-added National Project final report, Fitz-Gibbon (1997) suggests that it can also be reasonably predicted by their developed ability.

Due to the lack of prior value-added data for many classes or teachers participated in this thesis, the data to be used in this thesis are mainly collected from the prediction made on the basis of concurrent value-added approach. The author wants to carry out an investigation of the significance in predicting pupils' performance in maths and reading by their developed ability (i.e. verbal and non-verbal) as well as testing the significance of the links between prior-value added measures and concurrent value-added measures. It is also hoped that the study will enable readers with a better understanding of the calculation of outcome measures in the thesis.

Aims

The purpose of this study is to:

1. verify the statistical significance of making predictions of educational performance using context scores (i.e. 50% of picture vocabulary measure, 40% of problem of positions measure and 10% of home background measure) or average prior attainment (i.e. the average of maths and reading attainment in the previous academic year), and
2. investigate the extent of contributions of and the correlation between the two sets of outcome measures.
3. equip readers with a better understanding of the calculation of value-added with the use of practical data.

(2-1-4B) How to investigate?

Sampling

Basically, data in this study come from a convenient sampling procedure. The main reason is that the availability of prior value added data of a school in PIPS greatly depends on the participation of the school in the previous assessment year.

Presumably, data of the cohort would have been collected two years before collecting academic achievement data of current year.

As prior achievement data at pupil level is rarely available from the schools involved in this study, the present set of data is the only one that contains both prior achievement measures and concurrent achievement measures of several teachers in a target school in the thesis. One of the classes in this school is also involved in a research and development project reported in this thesis. Further description about the school is available in Chapter 6, section 6-5.

The availability of data for the specific investigation task acts as the major criterion for sampling.

Research hypotheses

It was expected that:

1. there is a link between pupil academic achievement (i.e. maths and reading) and:
    - the context score, or
    - the average prior attainment.
2. there is a link between the prior value-added measure and the concurrent value-added measure.

The first research hypothesis is assessed by two multiple regression models, predicting maths and reading attainment in 1997/98. In each model, the context score in 1997/98 or the average prior attainment in 1995/96 was used as the predictor. Pupil maths and/or reading attainment measures are derived from a PIPS test. An illustration of the content of the test is presented in Illustration I2-1A below. After administering the test, pupils' raw scores in maths and/or reading are converted into a standardised T-score (i.e. standardisation carried out at pupil level), which formed as the maths and reading attainment measures.

The second hypothesis is evaluated by a correlation test of prior value-added measure and concurrent value-added measure.

Illustration I2-1A: An example of each type of outcome measures in PIPS tests

THE ASSESSMENTS

The Year 4 assessments consist of 3 main sections: Contextual data
Mathematics
Reading.

Each section takes approximately half an hour to administer. With the exception of the reading test, every question is read aloud to the pupils taking part.

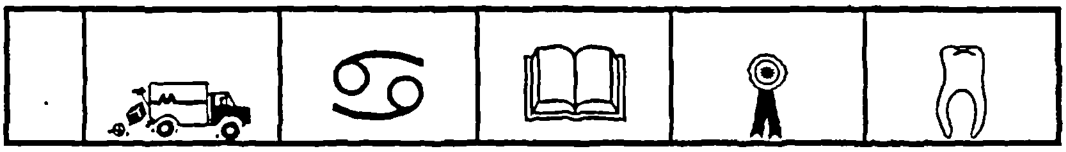
Contextual data

At present, in order to work out the Value Added scores, information is collected in relation to the pupils which is referred to as **contextual data.** This includes a picture vocabulary test, a non verbal ability test and a measure of home background. We know from research findings that schools have little effect upon these. Examples are shown below:

Picture Vocabulary

The administrator reads out a word. The pupil is required to draw a ring round the picture from a choice of 5 which they consider to represent the word.

For example:
The word for this question is vehicle.



Home background

In order to get a measure of home background pupils are asked questions such as :

When you are not at school do you visit museums and art galleries ?

No	Sometimes	Yes, often

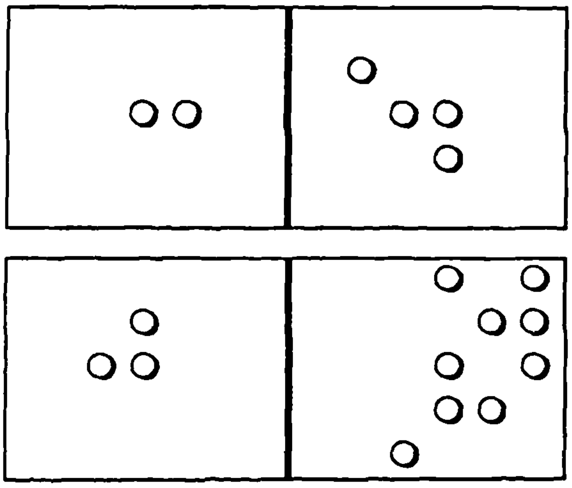
Non verbal ability

It is possible to measure non verbal ability using a culture fair test which determines the degree to which children are successful in recognising shapes and patterns. This Problems Of Position (POP) test was developed by an educational psychologist at Newcastle University.

The idea is that pupils join up the dots on the left hand side and then find and join up the same pattern of dots on the right hand side.

The POP test has a time limit during which the pupil has to work through as many questions as they can.

Example:



Attitude and self esteem

In addition to the above sections, we include a short questionnaire which provides pupils with the opportunity to express how they feel about aspects of reading and mathematics, as well as school life in general. This is presented in a way which is considered appropriate and enjoyable for children of this age.

I enjoy doing sums	☹	😐	☺
People are nice to me in school	☹	😐	☺

The achievement measures

The pupils' achievement in mathematics and reading is compared with their contextual score.

Mathematics

The Mathematics National Curriculum document was studied and questions were developed relating to each attainment target.

Below are 2 examples:

What number could ★ be in this sum?

★ + 4 = 20 ☐

Look at the numbers in the grid.

1	2	4	8
2	4	?	16
3	6	12	24
4	8	16	32

What is the missing number? ☐

Reading

This section consists of a series of activities designed to measure reading strategies and comprehension.

(2-1-4C) Why is this study adding value to the understanding of value-added measures in this thesis?

The results

The results of the linear regression models above are reported in Table T2-1-6 below. As all the ANOVA and all the estimation of beta coefficients are statistically significant at $p < .01$ level, the results confirm that both prior achievement or ability measures are significant predictor for reading achievement. The former explains about 45% of the variance in T-score and the latter explains about 44% of the variance. Similarly, both prior achievement or ability measures are also significant predictor for maths achievement. The former explains about 53% of the variance in T-score and the latter explains about 38% of the variance.

Generally speaking, the percentage of explainable variance reported in the studies above are lower than the figures mentioned in the literature review above. The major reason is the small sample size used in this study, when compared with the large sample size in studies mentioned in related literature. As the size of coefficient of determination is ranged from 0.61 to 0.73 and all of these estimations are statistically significant at $p < .01$ level, it means that each of the predictors are reasonably good at predicting the respective dependent variable.

Table T2-1-6: The results of linear regression models predicting academic performance in 1997/98

Dependent variable	Predictor	R-square	ANOVA (sig.)	Beta	Sig. of beta
maths score in 1997/98	context score in 1997/98	.38	.000	.61	.000
maths score in 1997/98	prior attainment in 1995/96	.53	.000	.73	.000
reading score in 1997/98	context score in 1997/98	.44	.000	.67	.000
reading score in 1997/98	prior attainment in 1995/96	.45	.000	.67	.000

Remark: The prediction was made on the basis of data of 70 pupils from three teaching groups of a school.

In the computation of value-added, a linear regression line will be plotted as a best fit line in each of the linear regression model above. Then the value-added (i.e. residuals) of individuals will be computed by working out the difference between the academic attainment in 1997/98 and the expected score on the linear regression line of the respective pupil. Finally, the computed residuals will be normalised (i.e. with the standard deviation equals to 1) at pupil level. This is the last step for the calculation of value-added data in this thesis.

Note that the computational step of value-added measures in this section is slightly different from the computational step in other value-added measures in this thesis. Raw reading residual scores are used here mainly because the exact number of pupils was unknown to the author and it hinders the normalisation process.

The second hypothesis is investigated by using the reading residuals and maths residuals computed by the PIPS project team after the regression line was plotted at pupil level with the use of data collected from a total of 2,026 Year 4 classes/teaching groups. The correlation between value-added in reading (i.e. reading residual) computed on the basis of prior achievement and value-added in reading computed on the basis of ability measure is 0.72. The correlation between value-added in maths (i.e. maths residual) computed on the basis of prior achievement and value-added in maths computed on the basis of ability measures is 0.76. The results lead to the conclusion that the two approaches of predicting value-added are linked closely to each other. Nevertheless, it might be worthwhile to note that "even if prior achievement measures are available, teachers may still want to look at concurrent general aptitude measures because there may be some pupils who have 'underachieved' throughout their school careers. These pupils could show satisfactory value-added measures but still be achieving below their potential (Tymms and Henderson, 1995, page 25)". The statement provides further justification for the use of cross-sectional value-added data, with the use of ability measures as predictors.

(2-2) Factors affecting effectiveness of teaching and learning: A review of models of effective teaching and learning

In this section, we shall review some models of effective teaching and learning. This will be followed by proposing a model of "effective curricular teaching and learning supported by computers and other types of ICT". The proposed model will be used as the basis for the investigation in other chapters in this thesis.

Learner's characteristics and effectiveness

Hallam and Ireson (1999) summarises the personal factors relating to the child's learning outcome as the list below:

"

- prior knowledge,
- age and development factors,
- abilities,
- conception of learning,
- meta-cognition,
- cognitive and learning styles,
- approaches to learning,
- motivation,
- effort,
- well-being,
- self-esteem,
- self-efficacy,
- gender,
- ethnicity, and
- social economic status.

(Hallam and Ireson, 1999)"

Researchers (e.g. Saunders, 1998 and Thomas, 1998) also identified some "factors" associated with educational progress, but over which individual schools or teachers have little or no control. These include:

- prior achievement
- sex
- ethnic group
- date of birth
- level of special educational need
- social disadvantage e.g. free school meal entitlement
- mobility

When considering all these variables together in PIPS (see Section 2-1-3E for detail), prior achievement is an outstanding factor in explaining pupils' achievement. It would enable researchers to predict about 50% of the variation in pupils' current test results. Social indicators only explain about 10% of the variation and pupils' home background cannot accurately predict their learning potential (Fitz-Gibbon, 1997). Saunders (1998) further reported that pupil's prior achievement and socio-economic background account for up to 80% of the variance in pupil performance between schools. In relation to the issue about the effect size of these factors, Mortimore and Whitty (1997) argue for better methods to control these two factors in value-added analyses. Fitz-Gibbon (1996) suggests the need to be cautious that "the effects of home background are already present in the measures of prior achievement or developed abilities". When looking at its impact at pupil level from multilevel modelling analyses, it only accounts for 9% of the variance in pupil performance

(Fitz-Gibbon, 1991). In line with this, Reynolds et. al. (1996, p.137) state that only 8% to 12% of the total variance in pupil achievement is contributed by the school. In primary schools, the effect size seems to be stronger than that of secondary schools.

A model with control for prior achievement would differ from another model with control of socio-economic factors. A model with control for both factors is likely to have a higher proportion of explained variance than each of the two independent models. Even so, one should note that a model with a lot of potential factors does not seem to be good at all because multiple regression is a maximizing procedure. The proportion of explained variance would increase even whenever an additional variable is put into the equation for making prediction. Fitz-Gibbon (1996) warns that it is "dangerous to include too many predictors in a regression equation" and suggests the need for "cross-validation".

We should also consider the fact that there were considerable time-to-time variations in educational progress. For instance, Tymms (1997) reported that at the end of key stage 2, the correlation between pupils' average English task levels (i.e. similar to pupils' average English marks/scores) in 1995 and in 1996 was 0.62, while the correlation between pupils' average maths task levels (i.e. similar to pupils' average maths marks/scores) in 1995 and in 1996 was 0.68.

Thomas (1998) also reported that some schools that may appear to be effective in terms of the overall progress may not be so effective for different groups of pupils. For example, different effects could be found between girls and boys and between pupils from different social backgrounds. These issues indicate the significance of internal variations in effectiveness within an institution.

The characteristics of effective schools

Perhaps the next question to be considered is "Besides pupil factors, to what extent do school and classroom factors affect pupil outcome?" According to Creemers (1994), about "12% to 18% of the variance in student outcomes can be explained by school and classroom factors when we take into account the background of the students". Sammons et. al. (1995) also suggested that the most modest estimation would be between 8% and 10%. Unfortunately, further differentiation between the contributions of schools and the classroom teaching is not available.

It might be worthwhile to note that the unique contribution of the effectiveness at school level is mainly the results of educational management and administration. These issues are not the topic of interest of this thesis. Instead, the focus of this thesis is on the effectiveness of learning and instruction, which includes effectiveness at pupil and teacher level. A brief summary of the major factors affecting school effectiveness in a "value added" perspective, is listed in Illustration I2-2A. Having said that, these school-level factors are reasonably different from the factors which focus on the effectiveness of learners and factors which focus on the effectiveness of instruction.

Illustration I2-2A: Factors affecting school effectiveness

ELEVEN FACTORS FOR EFFECTIVE SCHOOLS		
1	**Professional leadership**	*Firm and purposeful* A participative approach The leading professional
2	**Shared vision and goals**	Unity of purpose Consistency of practice Collegiality and collaboration
3	**A learning environment**	*An orderly atmosphere* An attractive working environment
4	**Concentration on teaching and learning**	Maximisation of learning time Academic emphasis Focus on achievement
5	**Purposeful teaching**	Efficient organisation Clarity of purpose Structured lessons Adaptive practice
6	**High expectations**	High expectations all round Communicating expectations Providing intellectual challenge
7	**Positive reinforcement**	Clear and fair discipline Feedback
8	**Monitoring progress**	Monitoring pupil performance Evaluating school performance
9	**Pupil rights and responsibilities**	Raising pupil self-esteem Positions of responsibility Control of work
10	**Home-school partnership**	Parental involvement in their children's learning
11	**A learning organisation**	School-based staff development

Source: From Sammons, Hillman and Mortimore, 1995.

The characteristics of effective classroom

The term "classroom" in this section refers to the teaching context. So, the scope of "effective classroom" will include the concepts of "effective teaching", "effective instruction" and "effective instructional environment".

To investigate the characteristics of an effective teaching context, some literature looked at the requirement of the subject curriculum as well as the requirement of the teacher. For example, in teaching literacy, Medwell et al prepared a list of things that literate children should be able to do by referring to the requirements of the National Literacy Project. They state that literate children should:

"

- read and write with confidence, fluency and understanding;
- be interested in books, read with enjoyment and evaluate and justify their preferences;
- know and understand a range of genres in fiction and poetry, and understand and be familiar with some of the ways that narratives are structured through basic literary ideas of setting, character and plot;
- understand and be able to use a range of non-fiction texts;
- be able to orchestrate a full range of reading cues (phonic, graphic, syntactic, contextual) to monitor and self-correct their own reading;
- plan draft revise and edit their own writing;
- have an interest in words and word meanings, and a growing vocabulary;
- understand the sound and spelling system and use this to read and spell accurately;
- have fluent and legible handwriting.

There are three strands to the experiences which children need to develop these competencies:

1. word level work: i.e. phonics, spelling and vocabulary,
2. sentence level work: i.e. grammar and punctuation,

3. text level work: i.e. comprehension and composition.

(Medwell et. al., 1998)"

The research "Effective teachers of literacy" looked at the characteristics of teachers whose pupils were making learning gains in literacy during the academic year. The judgement concerning effectiveness were made by their peers, their headteachers and inspectors, rather than on the basis of value added measures. As a summary of the main findings of the research, Medwell et. al. reported that effective teachers of literacy in the study tended to:

"

- Believe that it is important to make it explicit that the purpose of teaching literacy is enabling their pupils to create meaning using text. While almost all teachers would also endorse this aim, the effective teachers of literacy we studied were very specific about how literacy activities at the whole text, word and sentence levels contributed to such meaning creation.
- Centred much of their teaching of literacy around "shared" texts, that is, texts which the teacher and children either read or wrote together. Shared texts were used as a means of making the connections between text, sentence and word level knowledge explicit to children, both as a vehicle for teaching specific ideas at text, sentence and word levels and for showing how the features of words, sentences and texts work together.
- Teach aspects of reading and writing such as decoding and spelling in a systematic and highly structured way and also in a way that made clear to pupils why these aspects were necessary and useful.

- Emphasise to their pupils the functions of what they were learning in literacy. Thus the rules of grammar, for example, were not usually taught as discrete items of knowledge, but as connected features which would help children to improve their writing for specific purposes.
- Have developed strong and coherent personal philosophies about the teaching of literacy which guided their selection of teaching materials and approaches. These philosophies enabled them to pull together their knowledge, skills and beliefs in this area and helped give greater co-ordination to their teaching of literacy.
- Have well developed systems for monitoring children's progress and needs in literacy and use this information to plan future teaching.
- Have extensive knowledge about literacy although not necessarily in a form which could be abstracted from the context of teaching it.
- Have had considerable experience of in-service activities in literacy, both as learners and, often, having themselves planned and led such activities for their colleagues.
- Be, or have been, the English subject co-ordinator in their schools.

(Medwell et. al., 1998)"

In contrast, in the research project "Effective teachers of literacy", Askew et. al. (1997) introduces a broad working definition of numeracy:

"Numeracy is the ability to process, communicate and interpret numerical information in a variety of context."

By defining "effective" and "effectiveness" on the basis of learning gains, they found that highly effective teachers of numeracy believed that:

"

- being numerate requires having a rich network of connections between different mathematical ideas and being able to select and use strategies which are both efficient and effective;
- almost all pupils are able to become numerate;
- pupils develop strategies and networks of ideas by being challenged to think, through explaining, listening and problem solving;
- discussion of concepts and images is important in exemplifying the teacher's network of knowledge and skills and in revealing pupils' thinking;
- it is the teacher's responsibility to intervene to assist the pupil to become more efficient in the use of calculating strategies.

Askew et. al. (1997)"

Highly effective teachers of numeracy "had knowledge and awareness of conceptual connections between the areas which they taught of the primary mathematics curriculum". They used teaching approaches which:

"

- connected different areas of mathematics;
- used pupils' descriptions of their methods and their reasoning to help establish and emphasise connections and address misconceptions;

- emphasised the importance of using mental, written, part-written or electronic methods of calculation which are the most efficient for the problem in hand;
- particularly emphasised the development of mental skills;
- ensured that all pupils were being challenged and stretched, not just those who were more able;
- built upon pupils' own mental strategies for calculating, and helped them to become more efficient;
- encouraged purposeful discussion, in whole classes, small groups, or with individual pupils;
- used a variety of different assessment and recording methods to monitor pupils' progress and to record their strategies for calculating, to inform planning and teaching.

Askew et. al. (1997)"

In contrast, teachers who have low numeracy gains used teaching approaches which:

"

- dealt with areas of mathematics discretely;
- emphasised teaching and practising standard methods in isolation and applying these to abstract or word problems without considering whether there were alternative, more efficient ways of solving a particular problem;
- used assessment mainly as a check that taught methods had been learned rather than as a means of informing subsequent teaching;
- encouraged pupils to use practical equipment or any other method they felt comfortable with;

- dealt with areas of mathematics discretely, so as not to confuse the pupils.

Askew et. al. (1997)"

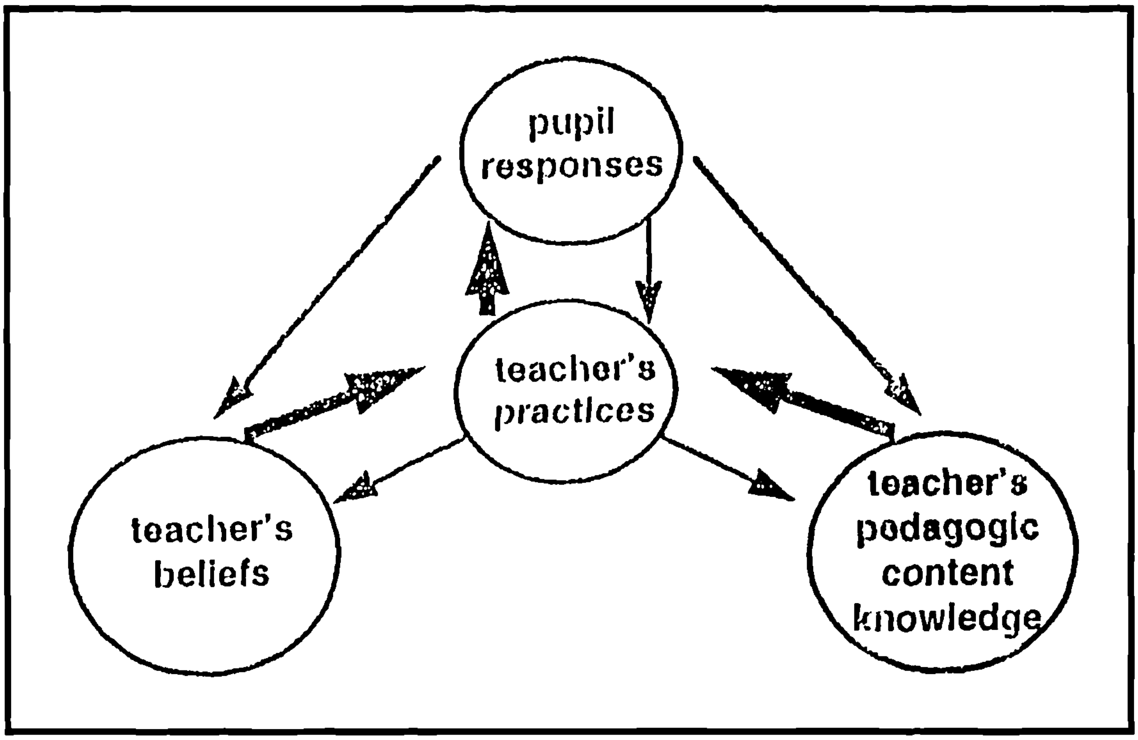
Both Medwell et. al. (1998) and Askew et. al. (1997) are interested in the teacher's belief systems and knowledge systems. They think that the two systems are the major determinants of the teacher's practices. The mechanism can be summairsed in Illustration I2-2B. In relation to the findings reported above, both of the two research teams have addressed three aspects of beliefs, including:

- beliefs about what it is to be a numerate or literate pupil,
- beliefs about how pupil learn to be numerate or literate, and
- beliefs about how best to teach pupils to be numerate or literate.

Both of the two research teams have addressed three aspects of knowledge, including:

- subject knowledge,
- pedagogical knowledge, and
- knowledge of pupils.

Illustration I2-2B: The relationships between the teacher's beliefs, knowledge and classroom practices (Source: Askew et. al., 1997, page 18)



It might be worthwhile to note that there is literature that looks at the characteristics of effective teachers from different perspectives. For instance, Cullingford (1995) suggested a list of factors affecting effectiveness in terms of teachers' personality without making a link to the subject they teach. They are summarised in Table T2-2-1 below.

Table T2-2-1: Personal characteristics of effective teachers

(Source: Cullingford, 1995)

Integrity	The quality of someone who is doing his best, modestly and without self-consciousness. No teacher is ever perfect, but every teacher can try to do better. Often we are doing better than we think we are.
Learning	The quality of enjoying learning and sharing a sense of curiosity. The process of learning is similar at all stages; and the teacher is also involved in learning. Teaching is a chance to gain knowledge and insight.
Organization	The quality of managing a classroom, with good preparation, clear rules and expectations, attention to detail, the best use of the classroom facilities, as well as knowing when to teach the class as a *whole*, *in groups*, *or individually*.
Communication	The quality of showing an interest in other people, both pupils and colleagues, and being able to demonstrate that interest through ideas, and stories, as well as through shared values.
Humour	We need a sense of humour to survive and to avoid being burdened with all our other virtues.

Harris (1998) described factors affecting educational effectiveness in terms of teachers' teaching skills on the basis of the results in Mortimore's study (1994). They are listed as below:

"

- Organisational - to sort out materials and sources of information;
- Analytical - to break down complex sources of information;
- Synthesising - to build ideas into arguments;
- Presentational - to clarify complex information without harming its integrity;

- Assessing - to judge the work of pupils so that appropriate feedback can be given;
- Managerial - to co-ordinate the dynamics of individuals, groups and classes;
- Evaluative - to improve teaching continually.

(Source: Harris, 1998 originates from Mortimore, 1994)"

Brophy and Good (1986) look at the relationships between teacher behaviour and student achievement. They have identified a range of teacher behaviour that affects student achievement. These factors are presented in Table T2-2-2.

Table T2-2-2: Teacher behaviour that affects student achievement

(Source: Brophy and Good, 1986)

Factor affecting student achievement	Further detail about the factor (i.e. teacher behaviours)
Quantity of pacing of instruction	• opportunity to learn/content covered • role definition/expectations/time allocation • classroom management/student engaged time • consistent success/academic learning time • active teaching
Grouping	• whole-class versus • small-group versus • individualised instruction
Giving information	• structuring • redundancy/sequencing • clarity • enthusiasm • pacing/wait-time
Questioning the students	• difficulty level of questions • cognitive level of questions • clarity of question • postquestion wait-time • selecting the respondent • wait for the student to respond
Reacting to student responses	• reactions to correct responses • reacting to partly correct responses • reacting to incorrect responses • reacting to "no response" • reacting to student questions and comments
Handling activities	• seatwork • homework assignment
Context-specific factors	• grade level • student SES/ability/affect • teacher's intentions/objectives • subject matter

In relation to the discussion about effective teachers of literacy or numeracy, readers have to bear in mind that the personality, skills and behavioural aspects of effective teachers are only components for effective teaching and instruction. There are other essential components e.g. teacher's beliefs, subject knowledge, pedagogy,...etc. It might be worthwhile to review some more literature and research findings of effective teaching.

"Effective instruction" has a similar meaning to "effective teaching", however, the scope of its meaning can be wider than the latter. It might be worthwhile to note that learning can take place without a teacher, and the teacher might not be physically present when learning takes place. For example, a child can learn by following the instructions of an activity book or of a computer software application. In line with this, Kamphaus, Yarbrough and Johanson (1990) discuss in detail the contribution of computer-assisted instruction to school psychology. So, the concept of "instruction" often covers and may go beyond the concept of "teaching".

A typical example of this is a list suggested by Algozzine and Ysseldyke (1995). They suggest that teaching activities are provided for each of the four components of effective teaching - planning, managing, delivering, and evaluating instruction. Teaching activities are also presented at three different levels - principles, strategies and tactics. The structure of the teaching principles for the four components of effective teaching is presented in Table T2-2-3 below.

Table T2-2-3: Teaching principles for four components of effective teaching (Source: Algozzine & Ysseldyke, 1995, page 5)

Components	Principles
Planning Instruction	Decide what to teach.
	Decide how to teach.
	Communicate realistic expectations.
Managing Instruction	Prepare for instruction.
	Use time productively.
	Establish positive classroom environment.
Delivering Instruction	Present instruction.
	Teach thinking skills.
	Motivate students.
	Provide feedback.
	Provide relevant practice.
	Keep students actively involved.
	Modify instruction.
Evaluating Instruction	Monitor student understanding.
	Monitor engaged time.
	Maintain records of student progress.
	Inform students of progress.
	Use data to make decisions.
	Make judgements about student performance.

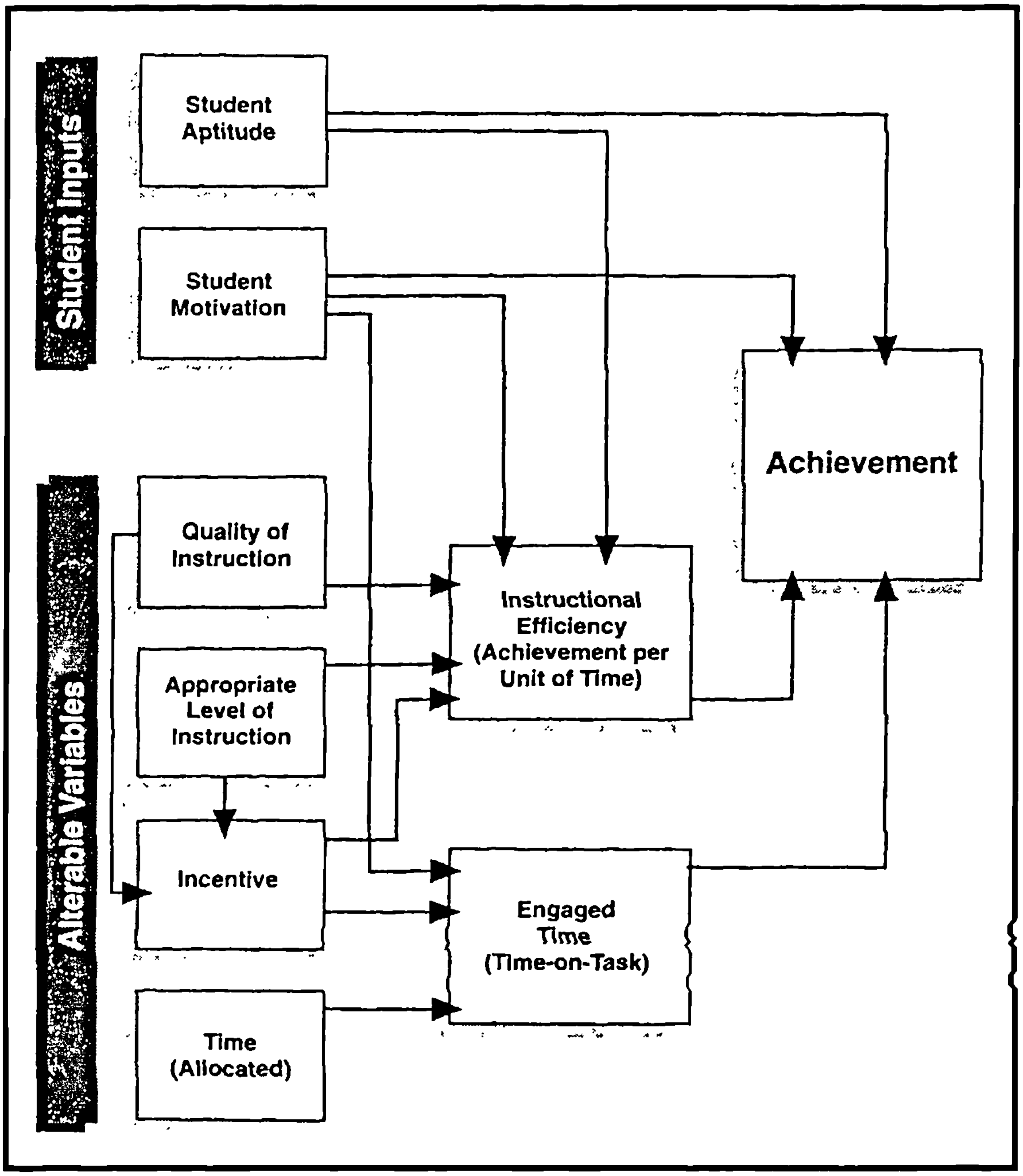
Readers may realise the ideas about effective teaching suggested by Algozzine and Ysseldyke (1995) are presented in a hierarchical framework. The tactics they suggest are guided by a group of strategies. These strategies are governed by a group of principles (as stated above), and the principles are guided by one of the four components of effective teaching. The ideas can be used as guidelines for effective instruction and/or improvements in instruction.

Another systematic presentation about effective instruction is proposed by Slavin (1995). He identifies critical elements of school and classroom organisation and their inter-relationships. By focusing on "alterable" elements, he proposes the QAIT model. The four major instructional elements proposed in the model are:

1. Quality of instruction,
2. Appropriate levels of instruction,
3. Incentive, and
4. Time.

The model emphasises that all the four elements must be adequate for instruction to be effective. The relationships between the four elements can be described as a "systematic". A graphical presentation of the model is available in Illustration I2-2C.

Illustration I2-2C: The QAIT model (Source: Slavin, 1995)



It is worthwhile to pay attention to several features of the QAIT model. Firstly, special attention is paid to "alterable" variables in education. It doesn't mean that student input variables are not completely unchangeable by classroom practices, however, they are greatly influenced by earlier instruction, specific training in thinking, problem-solving, or study skills, or by general intellectual stimulation or learning skills provided by the school. These variables are also changeable by classroom instruction in the long run. As our major interest is in the effectiveness of classroom instruction, the emphasis has to be placed on variables that can be directly altered by the school or teacher, while student inputs of this kind can be considered fixed. The idea is similar to the "value-added" approach in education in which the emphasis is placed on the pupils' "progress" made in the education process when compared with other pupils from similar intakes. We shall discuss the value-added approach in the next section.

Secondly, the effects of these "alterable" variables are mediated by two time-related variables - "instructional efficiency" and "engaged time", as presented in the model. After having a thirty-minute session in a classroom with high instructional efficiency, pupils will learn more than they will learn from a thirty-minute session in a classroom with low instructional efficiency. Similarly, pupils are likely to benefit more from learning activities in which they participate highly (i.e. paying attention to teaching and doing assignments) than learning activities in which they do not. Thirdly, the QAIT model emphasis the "multiplicative" relationship between instructional efficiency and engaged time. The implication is that it may be more effective to design instruction to produce moderate gains in both components than to maximize gains in only one. Slavin (1996a) suggests, "teachers need to be sure that if they solve problems relating to one element they do not cause new problems relating to another".

The Instructional Environment System - II (TIES-II) proposed by Ysseldyke and Christenson (1993) is another model of effective learning that has strong emphasis on the importance of the instructional environment. They clearly confirm their belief in Carroll's model of school learning in relation to the time factor. As in Illustration I2-

2D-1, they define instructional effectiveness on the basis of the time factor. The "degree of learning for an individual student" is defined as a function of the "time the student actually spends learning" divided by the "amount of time the student actually needs to learn. The emphasis on the time factor is fairly similar to the "instructional efficiency" factor in the QAIT model. However, unlike the QAIT model, the TIES-II authors think that there are many factors influence academic outcomes, in addition to the time factor. In reviewing literature about factors affecting instructional outcomes, they propose an extensive list of classroom and home factors. The list of factors is presented in Table T2-2-4.

Illustration I2-2D-1: A graphical presentation of interpretation of Carroll's (1963) model of instructional effectiveness

(Source: Ysseldyke & Christenson, 1993)

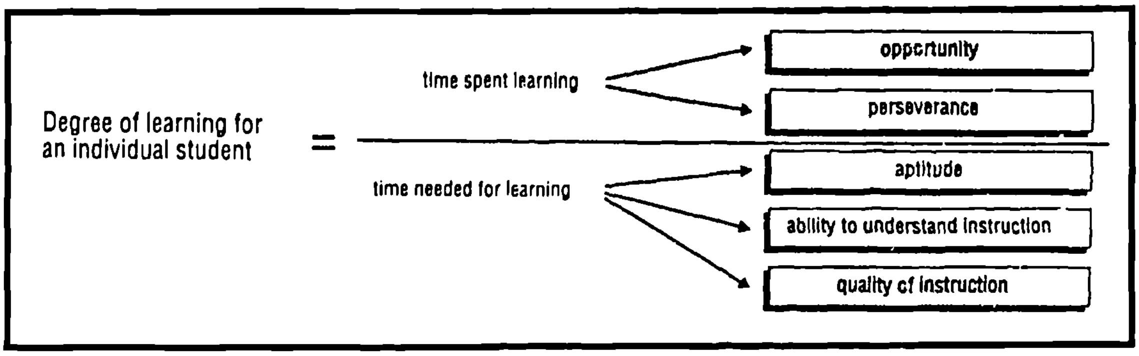


Table T2-2-4: Factors said to be or shown to be related to student outcome

(Source: Ysseldyke and Christenson, 1993, page 7-9)

Factor affecting academic outcomes	Detail descriptions of the factor
Student characteristics	• Cognitive and affective entry behaviors • Abilities (cognitive, psychomotor, psycholinguistic, etc.) • Prior learning or knowledge • Level of skill development • Ability to understand instruction • Motivation • Task persistence • Learning rate • Time needed to learn • Attentional set • Individual differences in locus of control, achievement, motivation, cognitive style, conceptual tempo, anxiety, attribution patterns, attitudes,...etc. • Learning styles • Cognitive types • Naturally occurring pupil characteristics (race, sex, physical appearance,...etc.)

Environmental factors	*School District Conditions* • Mileage rate • Teacher-pupil ratio • Extent to which there is an emphasis on basic skills • Amount of homework assigned • Emphasis on test-taking (including minimum competency testing) • Process by which the curriculum is developed • Attendance *Within-School Conditions* • Class size • School ambiance • Extent to which the school climate is fee from discipline problems • Leadership from the principal • Cooperative environment • Collaborative staff relations • Degree of structure • Clarity of classroom rules and procedures • Academic focus: high expectations *General Family Characteristics* • Status characteristics (Socioeconomic Status [SES], and the income level, educational level, and occupation of parents) • Use of out-of-school time • Peer group outside the school
Instructional Factors	*Planning instruction* • Sufficient time allocated to academic activities • Quality of the teachers' diagnosis of student skill level • Prescription of appropriate tasks that are clearly matched to student skill level • Realistic, high expectations and academic standards • Instructional decision-making practices (grouping, materials, ongoing diagnostic ability) • Sufficient content coverage • Instruction designed to include lesson presentation, practice, application, and review • Kind of curriculum (spiral vs. sequential) *Managing Instruction* • Efficient classroom management procedures • Well-established and efficient instructional organization and routines • Productive use of instructional time • Positive, supportive classroom interactions

	Delivering instruction • The Instructional sequence includes demonstration, prompting, and provision of opportunity for practice • Expectations (goals, objectives, academic standards) are communicated clearly • Lesson Presentation-Related Factors: - Extensive substantive teacher-pupil interaction, teacher questioning, signaling, explaining - Teacher-directed instruction (proceeding in small steps, carefully structuring learning experiences, etc.) - Clear demonstration procedures and systematic use of error correction procedures - High rate of accurate student response - Amount of guided practice prior to independent practice - Explicitness of task directions • Practice-Related Factors: - Amount and kind of independent practice - Appropriateness of seatwork activities - Systematic application of principles of learning to Instruction - High rates of academic engaged time (academic learning time; opportunity to learn) - Brisk, fast pacing (curriculum and lesson) - Degree of student accountability - Systematic, explicit feedback and corrective procedures *Monitoring and Evaluating Instruction* • Active monitoring of seatwork activities • High success rates (on daily and unit tests) • Frequent, direct measurement of pupil progress • Progress through the curriculum dependent upon on mastery criteria • Curriculum alignment (the relationship between what is to be taught [goals], what is taught [instruction], and what is tested [assessment])

On the basis of the factors affecting effectiveness above, Ysseldyke and Christenson proposed a list of 17 component factors that affect learning outcomes. Among these factors, 12 refer to classroom environment and 5 of those refer to home environment. They are presented in Table T2-2-5. On the basis of these components, the authors design observation forms, interview record sheets for the teacher and students as well as intervention planning form.

Table T2-2-5: The Instructional Environment System-II (TIES-II)

(Source: Ysseldyke and Christenson, 1993, page 13)

The 12 Instructional Environment Components	The 5 Home Support for Learning Environment
1. Instructional Match	1. Expectations and Attributions
2. Teacher Expectations	2. Discipline Orientation
3. Classroom Environment	3. Home Affective Environment
4. Instructional Presentation	4. Parent Participation
5. Cognitive Emphasis	5. Structure for Learning
6. Motivational Strategies	
7. Relevant Practice	
8. Informed Feedback	
9. Academic Engaged Time	
10. Adaptive Instruction	
11. Progress Evaluation	
12. Student Understanding	

Remark: Refer to Ysseldyke and Christenson (1993) for detailed descriptions of each of the components above.

The emphasis on "flexibility" is the major characteristic of TIES-II. Instead of simply proposing a model that fits for all learners, the TIES-II authors are concerned about how the individual learner adapts to his or her own learning environment. When a pupil is referred, school psychologists are responsible for assessing the instructional environment of an individual learner through observation and/or interviews. The assessments are defined as "ecological" by the authors because they specifically refer to the learner's own instructional environment. The data collected is used for planning and intervention purposes. So, the fundamental reason for the flexibility of TIES-II is that variables associated with the teaching and learning context are taken into consideration.

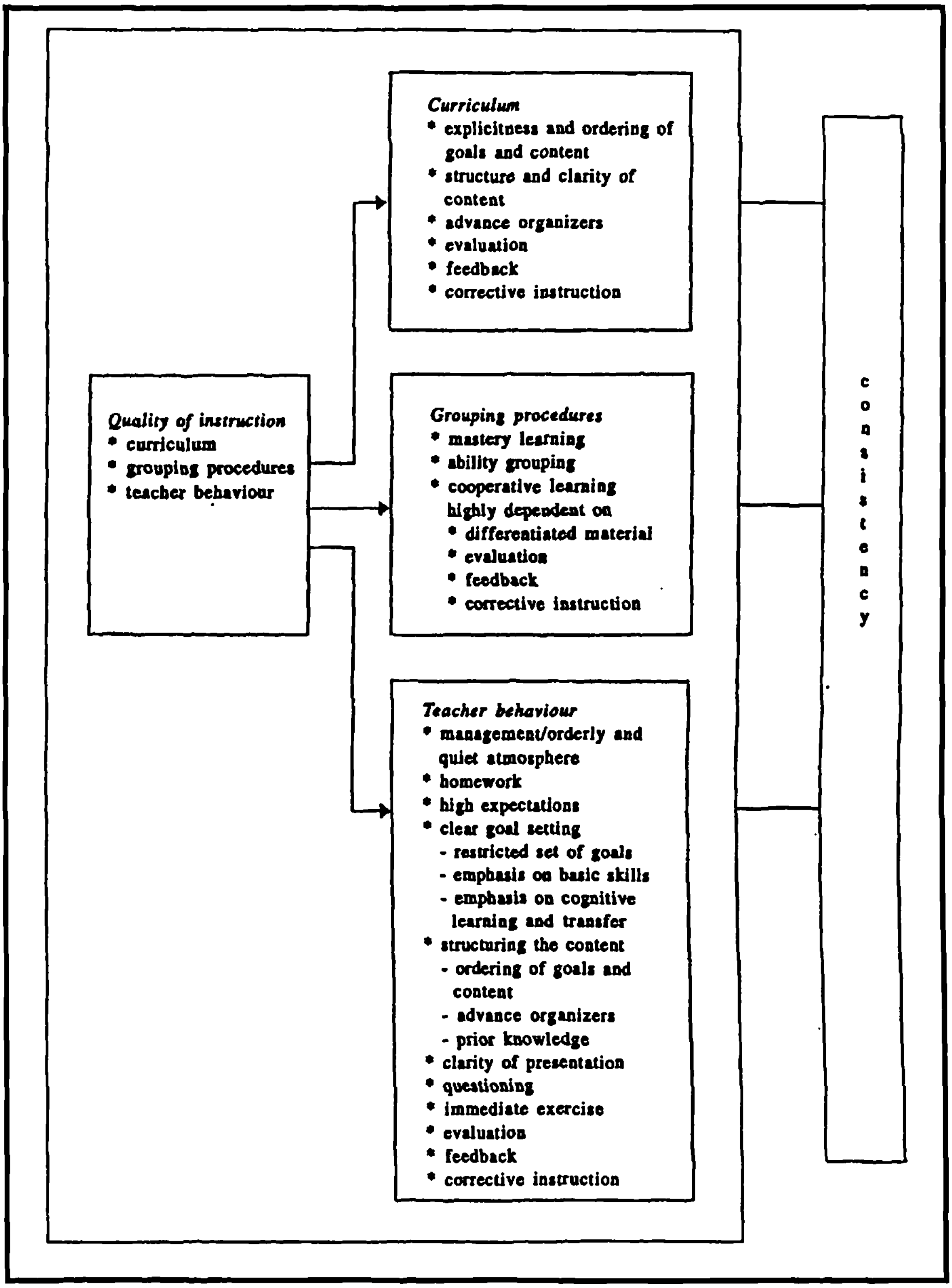
Further to QAIT, the model proposed by Creemers (1994) has an alternative view towards the relationship between quality of instruction and educational effectiveness. It suggests that the quality of instruction contains three major components. They are:

- curriculum,
- grouping procedures, and
- teacher behaviour.

Unlike many other models of educational effectiveness, Creemers thinks that each of these components of educational effectiveness contains a set of effectiveness-enhancing characteristics, which are quite similar across the three components. He stresses that the effective characteristics of each effective component have to be consistent with effective characteristics of similar nature. He states, "the same characteristics of effective teaching should be apparent in the different components. It is even more important that the actual goals, structuring, and evaluation in curricular materials, grouping procedures, and teacher behaviour are in the same line....In this way a synergetic effect can be achieved" (Creemers, 1994).

To move a step forward, the "Chaos theory" or "dynamic systems theory" of effective schooling (see Griffith, Hart & Blair, 1991 for detail) suggests that in a general state of disequilibrium of an organisation or a system, "small causes" may have "big effects" on the effectiveness of schooling (e.g. Scheerens, 1997; Tymms, 1994). In applying the idea to an instructional system in our discussion, instructional components or elements have their own role to play in the system. A problem associated with one of the instructional components or elements can possibly cause big negative impacts on the whole system when it is in a general state of disequilibrium. The theory is in line with, and is a step forward from, the idea of consistency between instructional components or elements suggested by Creemers (1994).

Illustration I2-2D-2: A model of educational effectiveness on the basis of the consistency between effective characteristics and components (Source: Creemers, 1994, page 12)



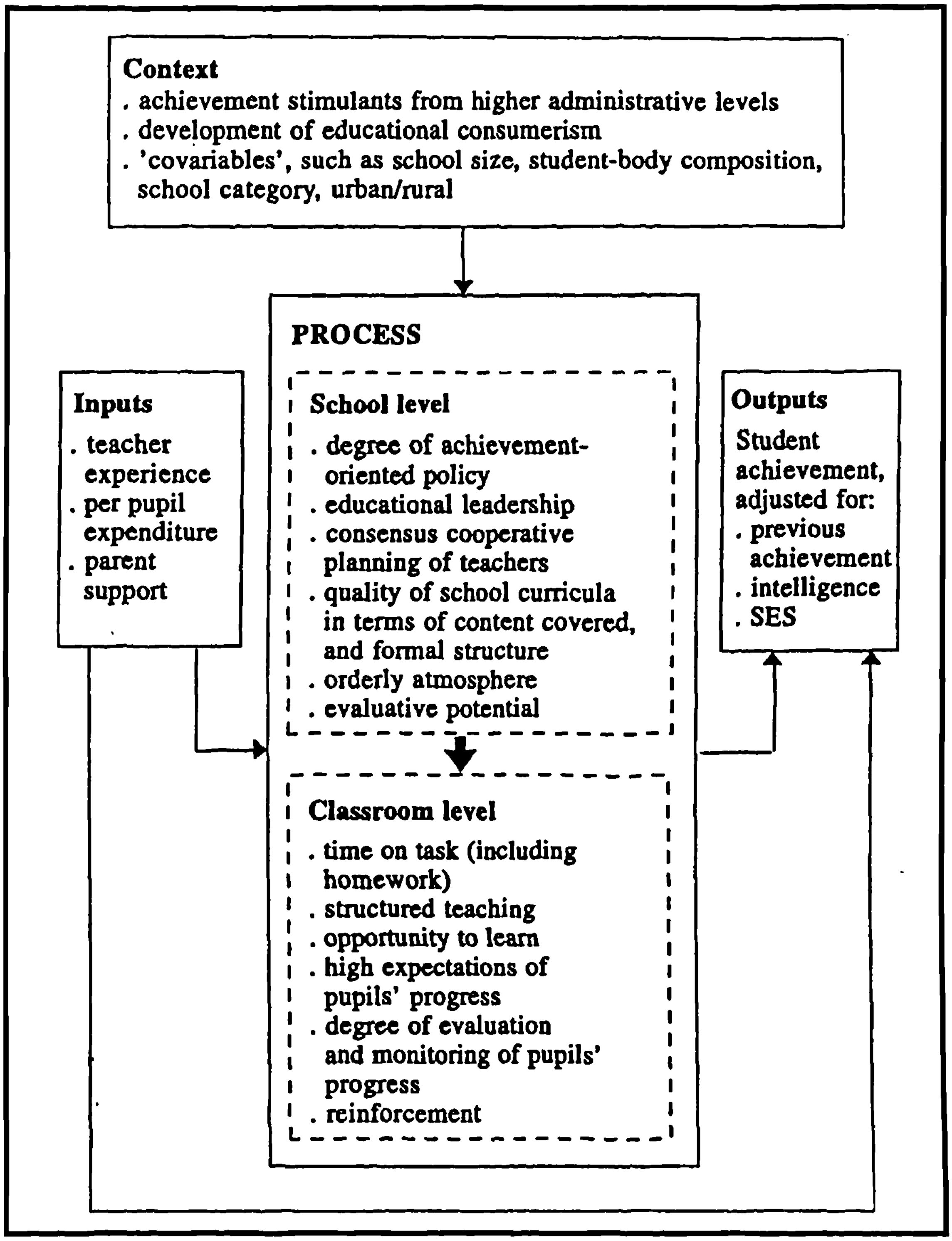
The model suggested by Creemers appears to be reasonably comprehensive. It bears the emphasis of the importance of "subject" or "curriculum" proposed by Askew et. al. (1997) and Medwell et. al. (1998), the importance of "grouping" identified by Brophy and Good (1986) as well as the importance of "quality of instruction" stressed by Slavin (1995, 1996a), Algozzine & Ysseldyke (1995) and Ysseldyke & Christenson (1993). Furthermore, the concept of "consistency" proposed by Creemers (1994) is reasonably compatible with the concept of "multiplication" stressed by Slavin (1995, 1996a). Both of them are in favour of preparing instruction as a system, rather than as isolated instructional elements. To be effective, these components work together simultaneously because they are complementary to some other elements in the instructional system. This lends support to the use of multiple regression technique in predicting learning attainment. We shall come back to this in Chapter 4 of this thesis.

Having said that, one of the limitations of the model above is that the relationships between the variables are assumed to be one-way in nature. In fact, many educational variables are bi-directional in nature. For example, the teacher may learn from the pupils when he/she teaches. The model above is not comprehensive enough to explain developments in the teacher's belief and knowledge systems, as the mechanism suggested by Askew et. al. (1997) does.

The last model to be reviewed here is an integrated model of school effectiveness proposed by Scheerens (1990). A diagram of the model is presented in Illustration I2-2E. The model has two major characteristics. Firstly, it adopts an input-output approach in analysing the productivity of schooling. Secondly, unlike other models in this section, this model has a multi-level structure. The effects of classrooms are nested in schools, and the effects of pupils are nested in classrooms or teachers. It is assumed that higher level conditions somehow facilitate lower level conditions. So, there are "cross-level" effects. Having said that, it may be worthwhile to note that the scope of this thesis rests on the effects at pupil level and at classroom level, but not the effects at school level.

Illustration I2-2E: A model of school effectiveness that shows the relationship between the effects at school level and at classroom level

(Source: Scheerens, 1990)



(2-3) A proposed model of teaching and learning supported by computers or other types of ICT

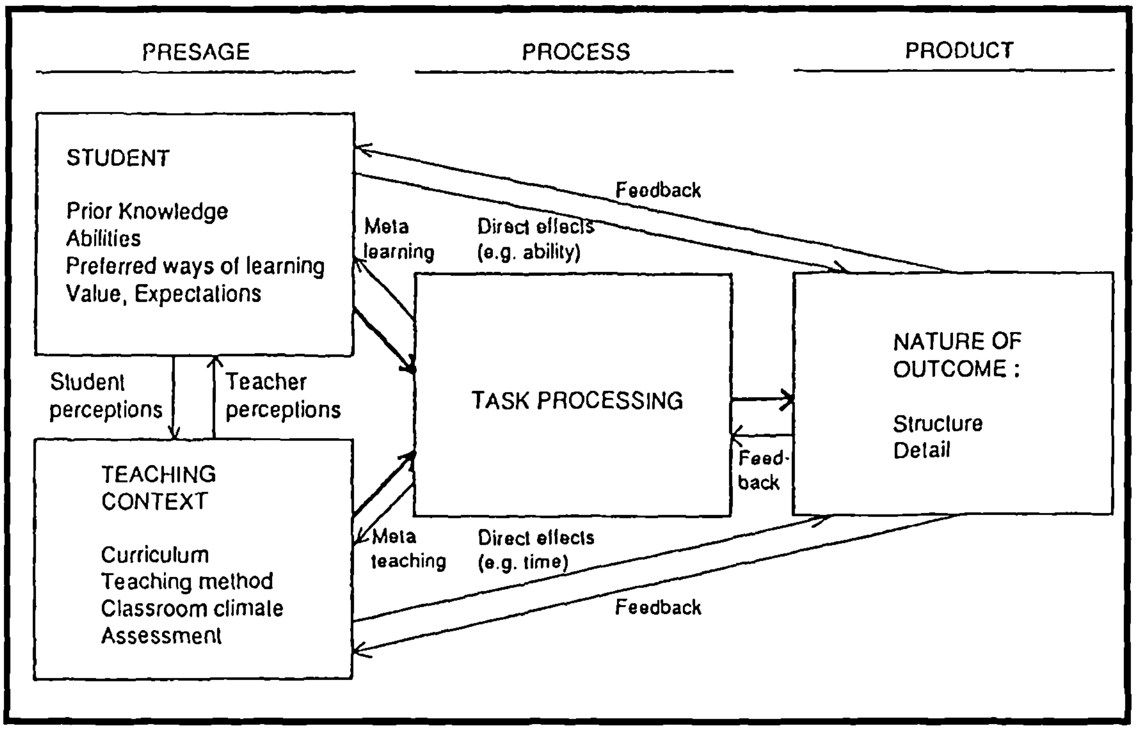
So far, we have looked at the characteristics of effective learners as well as the characteristics of effective classroom instruction. None of the models above are satisfactory in explaining the effectiveness of teaching and learning with or without the use of ICT. To move a step forward, it is worthwhile to consider integrating our knowledge about effective learning and effective teaching.

Biggs' 3P model is one of the most comprehensive models that incorporate learner characteristics and teaching context. A diagram of the model is presented in Illustration I2-2F. The model divides classroom learning into three stages: presage, process and product. Presage factors exist prior to the actual engagement in learning. It contains two major components, including student characteristics and teaching context. The factors in each of the two components interact. For example, "teachers' perception of students' motives or abilities influence their teaching decisions, while students' perceptions of the teaching context directly affect their motives and predispositions, and their immediate decisions for action" (Biggs, 1993a).

During the learning "process" stage, two types of mental activities are involved. These include cognitive processes and/or metacognitive processes. Activities of the former type involve the cognitive act of engaging or "processing" of the learning task. During the process, "meta-learning" may simultaneously take place. For example, a student may develop knowledge about how to tackle the learning task while he is processing it and a teacher may develop knowledge about how to teach while he/she is performing the teaching job. The learning product is mainly attributed to the processing of the learning task. It is also directly affected by the two components of the presage. For instance, the ability of the learner appears to be one of the "student input" factors that have a direct impact on learning outcomes, and the amount of teaching time also have a direct impact on learning outcomes. Nevertheless, feedback concerning learning outcome impacts on the learner, the teacher, and the learning process. The feedback affects the learner's future expectation, motivation, and learning decision and it might further affect the teacher's decisions about future teaching.

Illustration I2-2F: The 3P Model of Classroom Learning

(Source: Biggs, 1993a, page 8)



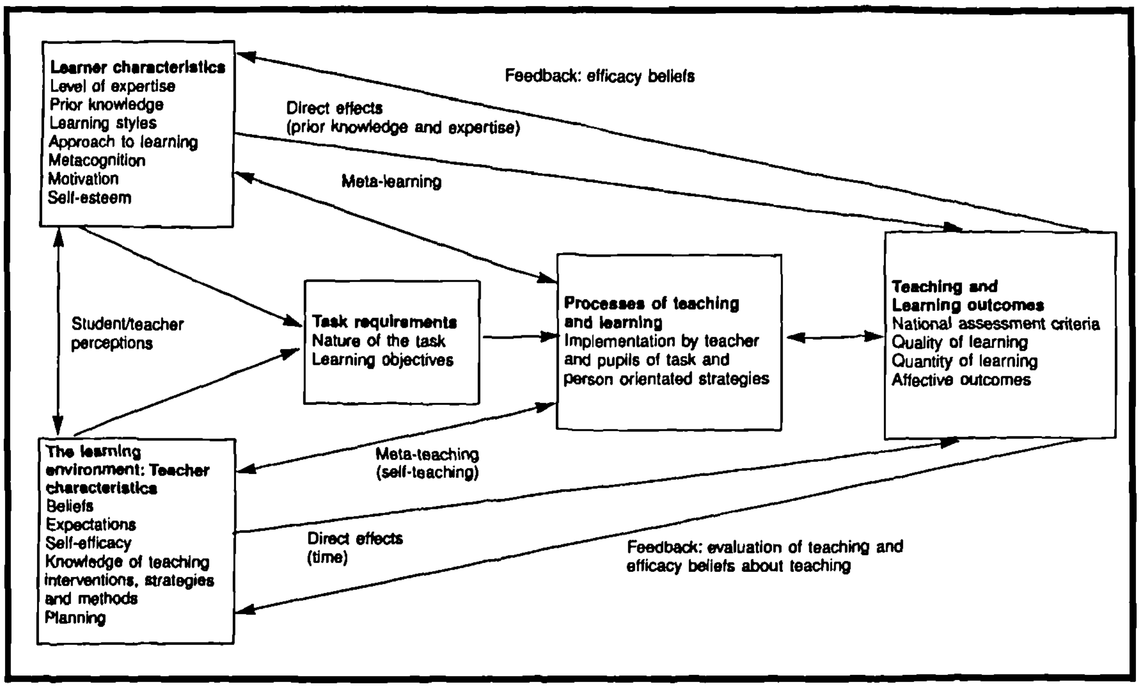
So far, it might be worthwhile to draw attention to some of the characteristics of Biggs' 3P model. Firstly, it distinguishes different stages of teaching and learning, and it considers them together as a two-way flow integrated system. Secondly, the model considers learners' characteristics and teachers' characteristics. In theory, the characteristics of effective teachers identified by Brophy and Good (1986) is included as a part of the teaching context in Biggs' model. Thirdly, the impact of the "teaching context" is treated as one of the major determinants for the "learning context" in the task processing stage. The importance of "subject" or "curriculum", as proposed by Askew et. al. (1997) and Medwell et. al. (1998), is considered as a part of the teaching context. Fourthly, similar to Slavin (1995, 1996a), Algozzine & Ysseldyke (1995) and Ysseldyke & Christenson (1993), the model stresses the importance of the "quality of instruction". It considers the impact of teaching method on the learning process as well as meta-teaching. It provides the basis for teacher learning and development through teaching practices. Fifthly, Biggs (1993b) considers the application of the model as several nested micro-systems. A number of student systems are nested within the classroom system. A number of classroom systems are nested within the institutional system, and a number of institutional systems are nested within the community system. At classroom level, Biggs states, "the equilibrium here involves teacher perceptions of student competencies and curriculum needs, setting of tasks, students perceptions of task demands, teaching and learning processes, and learning outcomes. Where disequilibrium exists, accommodation occurs. For example, perceptions of task demands that do not match perception of teaching processes can either lead to low level outcomes, or to attempts by students to supplement teaching" (Biggs, 1993b). It is obvious that the model has considered educational effectiveness from a multi-level perspective.

Having said that, it might be worthwhile to note that there are limitations in the scope of the model and its application. Firstly, the model does not clearly describe the effects of "grouping", which is identified as one of the factors affecting the effectiveness of education. Secondly, the setting of aims and objectives of the learning task is not clearly defined in the model. Theoretically speaking, this is the starting point of the teaching process and it is likely to happen before the learning process begins. Thirdly, like many models of educational effectiveness or models of teaching and learning, the role of ICT or resource-based teaching does not have a unique role in the model.

In line with the second point above, Hallam and Ireson have made an attempt to update Biggs' model of teaching and learning with considerations of the requirement of the learning task. A diagram of the revised model is presented in Illustration I2-2G.

Illustration I2-2G: A revised 3P model

(Source: Hallam & Ireson, 1999, in Mortimore (Ed.), page 79)

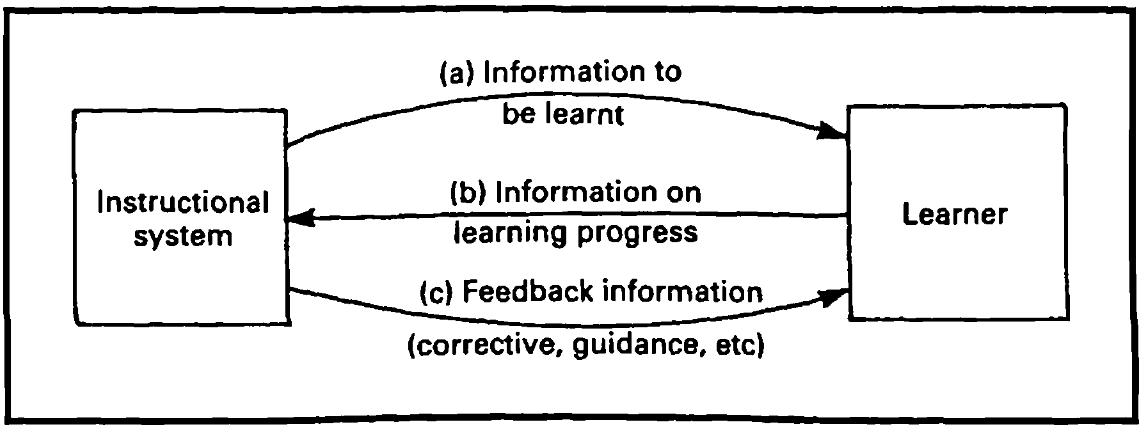


The majòr revision proposed by Hallam and Ireson (1999) is the addition of the "task requirements" component of teaching and learning to the 3P model. The new component is determined by learners' characteristics and by the teaching context. Besides the two presage components suggested in Biggs' 3P model, the component becomes an additional factor that affects the "process" stage of teaching and learning. So, it is obvious that Hallam and Ireson have noticed the limitation of the 3P model in explaining the importance of a teaching plan.

As the relationship between the "task requirements" components and the "processing of teaching and learning" is defined as a one-way flow system, the model is unable to explain changes or adjustments in teaching plans. For instance, teachers may need to change their pre-set requirements of the learning task when they have discovered that it is too difficult for most of the pupils in class to achieve. Furthermore, in a resource-based learning system, computers or some other ICT nowadays can select and/or make adjustments to the instruction in response to the learner's specific needs. That means, the relationship between "task requirements" and "processes of teaching and learning" is likely to be interactive in nature. We shall come back to the latest development of the 3P model later.

As the major interest of this thesis is in teaching and learning supported by computers or other types of ICT, it would be good to review several learning models constructed from an instructional design perspective. Readers have to bear in mind that teachers may and may not be directly involved in the learning process, which is reasonably different from other teaching and learning models. The first model to be reviewed here is proposed by Romiszowski (1988) and it also has close alignments to the interactive relationship between "task requirement" and "processes of teaching and learning" above. A diagram of the model is presented in Illustration I2-2H.

Illustration I2-2H: Three essential types of communication during the instructional process (Source: Romiszowski, A.J., 1988, page 7)



In the model, the instructional system transmits a variety of messages to the learner. These include the task requirements, the content and the procedure of the learning tasks. In return, the instructional system may receive information on learning progress from the learner. The received information may lead to two types of response to the learners. These include adjustments of the information to be learnt and/or providing feedback information to the learner. Computer-managed instruction can be an example of the former type. Information on learning progress can help in the selection and/or making adjustments to the information to be transmitted to the learner in order to suit for the learner's individual needs. The change of task requirement could be an example of adjustments of this type. Information on learning progress also facilitates the provision of feedback to the learner. For example, the learner may need some corrective feedback or other forms of guidance in learning.

Romiszowski (1988) has particular interest in outlining various factors that may affect the choice of media. An attempt is made to summarise the inter-relationships between the major factors as a diagram. This is presented in Illustration I2-2I. In the model, five major factors affecting media selection are proposed. These include:

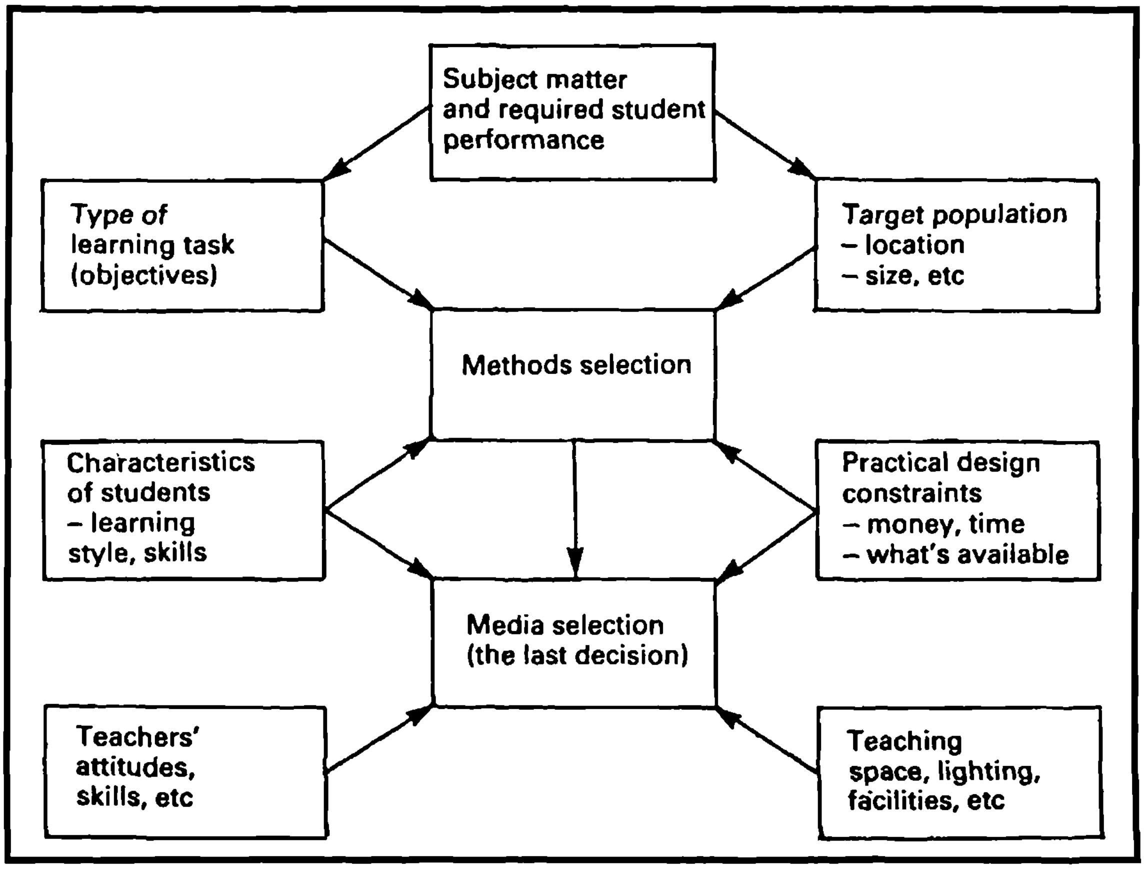
"

- instructional method e.g. one-direction medium of presentation doesn't seem to be suitable for instructions aiming at sharing of experience,
- learning task i.e. it limits the choice of suitable methods of instruction and affects the media choice,
- learner characteristics e.g. consider pupils' IT skills before the decision of using computers is made,

- practical constraints e.g. administrative and economic factors affecting the media choice, and
- human factors e.g. teacher's teaching preference.

(adapted from Romiszowski, 1988)"

Illustration I2-2I: A basic media selection model
(Source: Romiszowski, 1988, page 37)



Furthermore, Rowntree (1994) thinks that the matching between learning tasks and instructional media is an important step for the planning and development of instructional materials. The author suggests that designers of instructional materials analyse the instructional match between the two. One of the ways of doing it is to do it as a chart format, as presented in Illustration I2-2J.

Illustration I2-2J: An example of analysis of the match between learning tasks and possible instructional media (Source: Rowntree, 1994, page 68)

Some possible media →

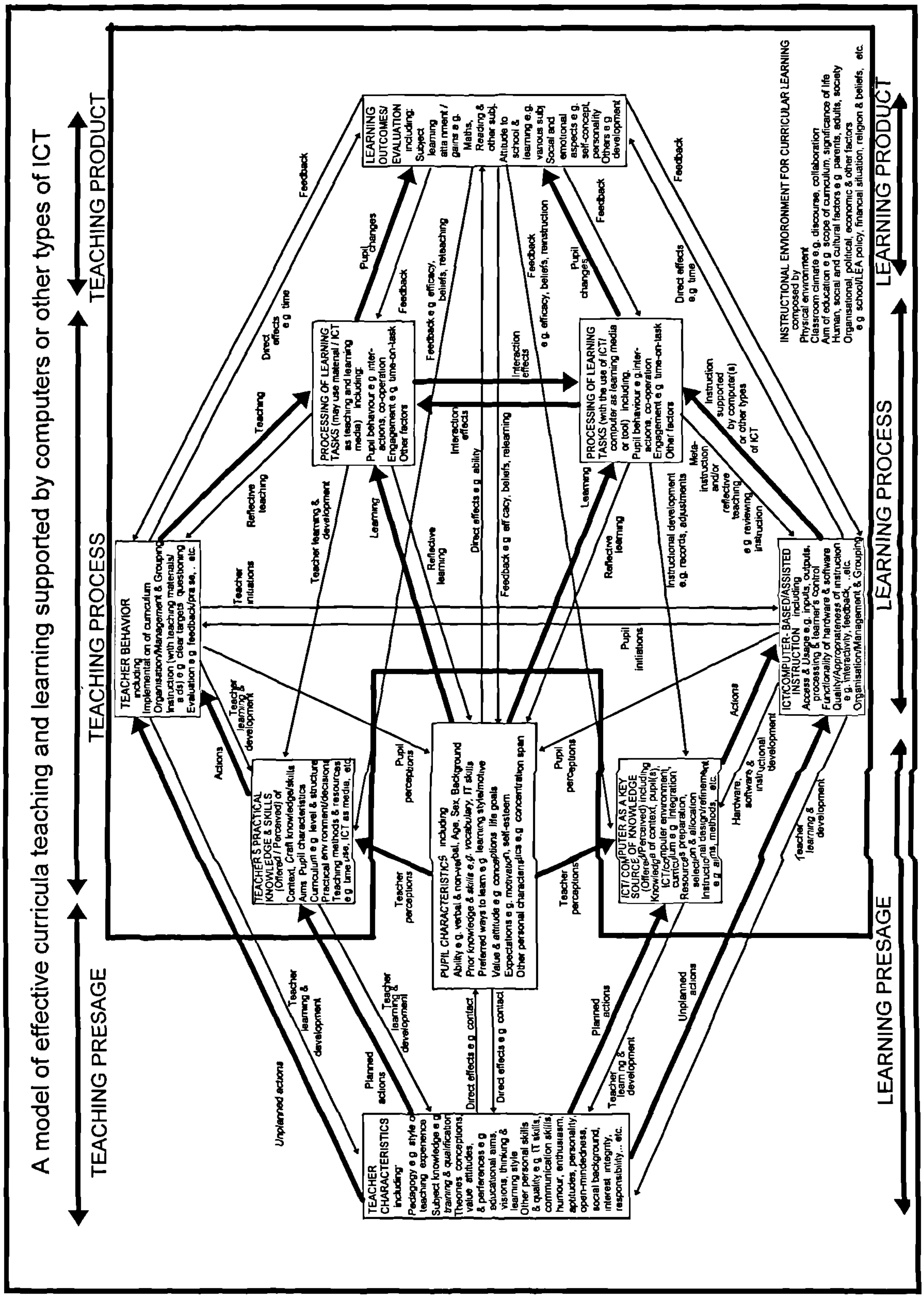
Things you might want to do in your teaching	Print	Audio	Video	Interactive video	Practical work	Computer tutoring	Computer simulation	Multi-media	Computer conferencing	Lecturing	Face-to-face tutoring	Telephone tutoring	Correspondence tutoring
• Provide a carefully-argued analysis of your subject.	✓	✓								✓			
• Convey the sights, sounds and spirit of your subject.		✓	✓	✓	✓		✓	✓					
• Build each learner's ideas into the teaching.					✓		✓		✓		✓	✓	✓
• Ask learners to answer questions about the subject.	✓	✓	✓	✓		✓		✓	✓		✓	✓	✓
• Enable learners to try things out, physically.					✓		✓						
• Ensure that learners get physical feedback from the real world.					✓		✓						
• Give learners standardized verbal feedback according to what category of response they make.	✓	✓		✓		✓		✓					
• Give each learner unique, personal feedback.									✓		✓	✓	✓
• Continuously alter the teaching to suit each learner's current needs.											✓	✓	✓
• Provide learners with a record of the learning experience.	✓												
• *Others? (What?)*													

On the basis of results of the analysis in Illustration I2-2J, the first seven learning tasks can be achieved effectively by using print and computer simulation. Alternatively, the instructional designer may use print and practical work.

Nevertheless, to achieve the purpose of using computers effectively for teaching and learning, teachers and pupils have to work collaboratively together. Perhaps Laurillard's (1993) conversational model is the most well-known mechanism for this purpose. A diagram of the model is presented in Illustration I5-2B in Chapter 5. We shall have further discussion about it when we address the issue about teacher development and its relationship with the use of ICT.

So far, we have a review of various models of teaching, learning and instruction. It is obvious that these models have their own strengths and weaknesses. In particular, none of them is comprehensive enough in explaining the mechanism of teaching and learning with and without the use of ICT. Having said that, for the purpose of this thesis, there is a need to have a model of this type to be a framework guide and to explain specific phenomena in the thesis. It gives the background for proposing "a model of effective curricular teaching and learning supported by computers and other types of ICT" in this section. A diagram of the model is presented in Illustration I2-2K.

Illustration I2-2K: A model of effective curricular teaching and learning supported by computers and other types of ICT



Remark: The model is also prepared as detachable sheet by the author - Harrison Kar Him TSE, in his PhD thesis "Promoting the effective use of computers to support the learning and teaching of literacy and numeracy in primary education with attention to pedagogy, teacher reflection and development" submitted to the University of Newcastle upon Tyne.

The proposed "model of effective curricular teaching and learning supported by computers or other types of ICT" is presented in Illustration I2-2K. As in Biggs' 3P model (1993b), it is comprised of three major stages of teaching and learning. It also attempts to link teacher, learner(s) with learning tasks and learning outcomes to form an integrated system. Each of the boxes in the diagram represents a key component of teaching and/or learning. There are also one-way arrows joining components in the model. They are used to show the causal relationships from a component of the model towards another component.

Generally speaking, the arrows pointing from left to right sides of the diagram show the direct or indirect contributions of the respective components of teaching and learning toward learning outcomes. The arrows that are printed in bold represent the major effects because the contributions that these components made on learning outcomes are large and crucial. The arrows pointing from right to left represent feedback or review that involves reflection. They make direct and/or indirect contributions to personal characteristics, including those made by the teacher and the pupils. The paragraphs below will explain more about the model, starting from a general framework of teaching and learning without the use of ICT in the upper part of the model. This will be followed by an attempt to establish a parallel framework of learning and instruction supported by computers or other types of ICT from a resource-based teaching perspective.

Teacher and pupil(s) are the key parties in the model. Each of them has his/her own characteristics and his/her role to play. One teacher may differ from another in terms of experience, teaching style, pedagogy, qualifications, training, knowledge of the subject, personal conceptions, value, attitudes, educational aims and preferences, ability, skills, personality...etc. One pupil may differ from another in terms of ability, age, gender, social and racial background, prior knowledge, skills, preferred ways to learn, conceptions, life goals, motivation, self-concept,...etc. As time goes by, the characteristics of an individual may change in relation to his/her life experience. These personal characteristics exist before the start of the teaching and learning processes. They are the key elements of the two components of the presage of teaching and learning.

One of the features of this model is the consideration of the discrepancy between the time when teaching and learning processes begin. The teaching process is regarded as a stage that starts before the learning process. It is proposed that teaching actually begins by teacher's perception of pupil characteristics and their educational needs. The perception leads to lesson planning and preparation, which may take place before the process of pupil learning begins. In the planning and preparation, the teacher has to offer a combination of his or her practical knowledge and skills about the teaching and learning aims, methods, resources, learning context and about the curriculum, classroom environment...etc. Learning begins when pupil(s) perceive(s) the behavioural actions of the teacher, which includes the instructional context prepared by the teacher. It often takes place in the classroom. The effectiveness of teaching behaviour depends on factors such as classroom organisation, management, grouping, quality of instruction, the way the curriculum is implemented, and the use of evaluation and feedback.

Note that not all teacher behaviour consists of planned actions. In daily classroom practices, often the teacher needs to handle unexpected events. Taking unplanned actions may become unavoidable in practice. These actions are greatly affected by the personal characteristics of the teacher. For example, generally speaking, teachers who have good subject knowledge will be more competent in tackling complicated issues about the subject than teachers who lack subject knowledge. Teachers who are trained and/or experienced in handling children with special educational needs are likely to be more capable in handling maladjusted/deviant behaviour in the classroom than those who are untrained and/or inexperienced in this area. Teachers who are trained and/or experienced in using ICT for subject teaching are likely to be more capable in handling problems associated with the use of ICT than those are untrained and/or inexperienced in using ICT. Planned actions are thoughtful and/or reflective in nature. They may take place as actions with the application of learnt knowledge or actions with critical evaluation of existing knowledge. Unplanned actions tend to be spontaneous if the job to be done is a routine. However, especially when tackling unexpected problems, it is possible that unplanned actions are taken after thought processes or reflection. This is the reason why Schon (1987) thinks that professionals need to develop the skill of reflection-in-action, which facilitates professional practice and professional development.

In referring to the use of computers or ICT, the decision of using computers or ICT as a key source of knowledge is often made at the lesson planning stage. The teaching process may begin by the teacher's awareness of the pupils' needs and their thinking or reflection about the potential contributions that computers or ICT may bring. In the planning and preparation, the teacher has to offer a combination of his or her practical knowledge and skills about the resource, such as its aims, methods, instructional design...etc. For example, the teacher may need to make decisions about hardware and software selection, about resource allocation, about introducing IT as part of an integrated curriculum or as a separate subject. Some teachers may be directly involved in the design of the computer/ICT-based material, may adapt the material or prepare supplementary material. The teacher also needs to offer practical knowledge about the pupils, the computer/ICT-related learning environment, the teaching and learning context and pay efforts to prepare the learning environment for their pupils. Learning begins when pupils have gained access to the computer or ICT. Pupils are the primary users of the computer or ICT. Sometimes, the teacher or other helpers may work together with the children. For example, for very young children, the teacher may be responsible for the operation of hardware and software. In addition to the instruction provided by the equipment, the teacher may also give instructions. In a pure computer-based or resource-based learning environment, the information on the computer is the only source of knowledge for pupil learning. In a computer-assisted learning environment, pupils may learn from instructions provided by the computer as well as from the instructions provided by the teacher. The effectiveness of ICT/computer-based/assisted instruction depends on factors such as the quality and appropriateness of instruction, the provision and functionality of equipment, classroom organisation, management, grouping,...etc. To achieve effective learning, activities with the use of computers and activities without the use of computers have to be consistent, supporting each other. The integration of ICT activities and non-ICT activities is a factor affecting instructional effectiveness.

Pupils' behavioural actions in the processing of learning tasks are mainly affected by two components of the model. These include teacher behaviour and pupil characteristics. In particular, the importance of pupil characteristics is fundamental because the learner is the key person responsible for his/her learning behaviour. The personal characteristics of the pupil are factors in the learning presage because they exist before learning begins. These factors include ability, background, prior knowledge, skills, value, attitudes, conceptions, motivation, expectations, learning styles/approaches…etc. In the model, pupils' behavioural actions in the processing of learning tasks are determined by the tensions between the two components of teaching and learning. For examples, a pupil's low engagement in the learning task could be attributed to his/her short concentration span, a negative attitude towards the learning tasks, the lack of prior knowledge, and/or some other factors associated with the teacher's behaviour. When teaching and learning takes place in a learner-centred way, pupil characteristics may have a greater influence than teacher behaviour. Alternatively, when teaching and learning take place in a teacher-centred way, pupil characteristics may have a smaller influence than teacher behaviour.

In the model, the term "reflective teaching" is used to replace Biggs' concept of meta-teaching. It is a type of teacher learning and development that involves reflection. The term "reflective learning" is used to replace Biggs' concept of meta-learning. It is a type of pupil learning and development that involves reflection. In other words, learning and development can take place without involving reflection. Habitual action or routine is a typical example. A detail description of the concept of reflection is presented in Chapter 5 section 5-1-1. Nevertheless, the book written by Kember et. al. (2001) is also a good source of reference.

A pupil may improve his/her own way of learning when he/she is engaged in learning. Similarly, a teacher may improve his own way of teaching when he/she is engaged in teaching. Through reflection, information about the processing of learning task not only have impacts on teacher behaviour, but also have impacts on the teacher's practical knowledge and skills. This kind of perception (or awareness) makes a contribution to teacher learning and development. Nevertheless, pupils' perception of the behavioural actions of the teacher may have some effect on pupils' behaviour in the processing of the learning task(s). For instance, when pupils perceive that the teacher is expecting factual information, it is likely that the pupil will prefer using a surface approach of learning for the learning task.

In referring to the use of computers or ICT, pupils' behavioural actions in the processing of learning with the use of computers or ICT are mainly affected by pupil characteristics and ICT/computer-based/assisted instruction. For instance, a pupil's low engagement in the computer-based/assisted learning task could be attributed to the functionality and quality of hardware and software, the quality and/or appropriateness of instruction, the improper handling and/or usage of the computer/ICT-related resources, and/or some other factors associated with pupil characteristics. A common barrier for engagement in the processing of learning tasks is poor IT skills and operation. Meta-instruction and reflective teaching also take place in a computer/ICT-based/assisted learning environment. To be accurate, they are named "meta-instruction" and "instructional development". The former refers to the improvement and adjustments in instruction on the computer by making use of information about the pupil's processing of learning tasks. Computer-managed instruction (CMI) is a typical example of this kind because it makes use of the information to prepare a better learning environment for the pupil according to his/her individual needs. Some software applications (e.g. some Integrated Learning Systems) record information about the progress and/or achievements made by individuals on the computer and the information used in the next computer/ICT-based/assisted learning session, teacher record and/or in planning interventions. Unlike meta-instruction that focuses on the operation of computers or ICT, this kind of information contributes to the knowledge database of the computer/ICT. Such processes are called instructional development in the model.

One of the characteristics of this model is that the processing of learning has to be within the large box "instructional environment for curricular learning". This component of teaching and learning not only includes the scope of the curriculum, but also the physical, psychological, social, organisational and cultural environment where teaching and learning take place. In other words, it contains society's expectations about education and the environmental attributes associated with its occurrence. The position of the processing of a learning task can be described as an "equilibrium" through various framing and re-framing of the teacher's pedagogy in an applied teaching and learning context. Its position is determined by the tension between the effects of teacher behaviour, pupil characteristics and the evaluation of learning outcome. For example, in a teacher-centred classroom environment, the position of the processing of learning tasks would likely be closer to the teacher behaviour than to the pupil characteristic component of the model. In a pupil-centred classroom environment, the position of the processing of learning tasks would likely be closer to the pupil characteristics than to the teacher behaviour component of the model. In an assessment/evaluation-oriented classroom environment, the position of the processing of learning tasks would likely be closer to the learning outcomes/evaluation than the other two components of the model.

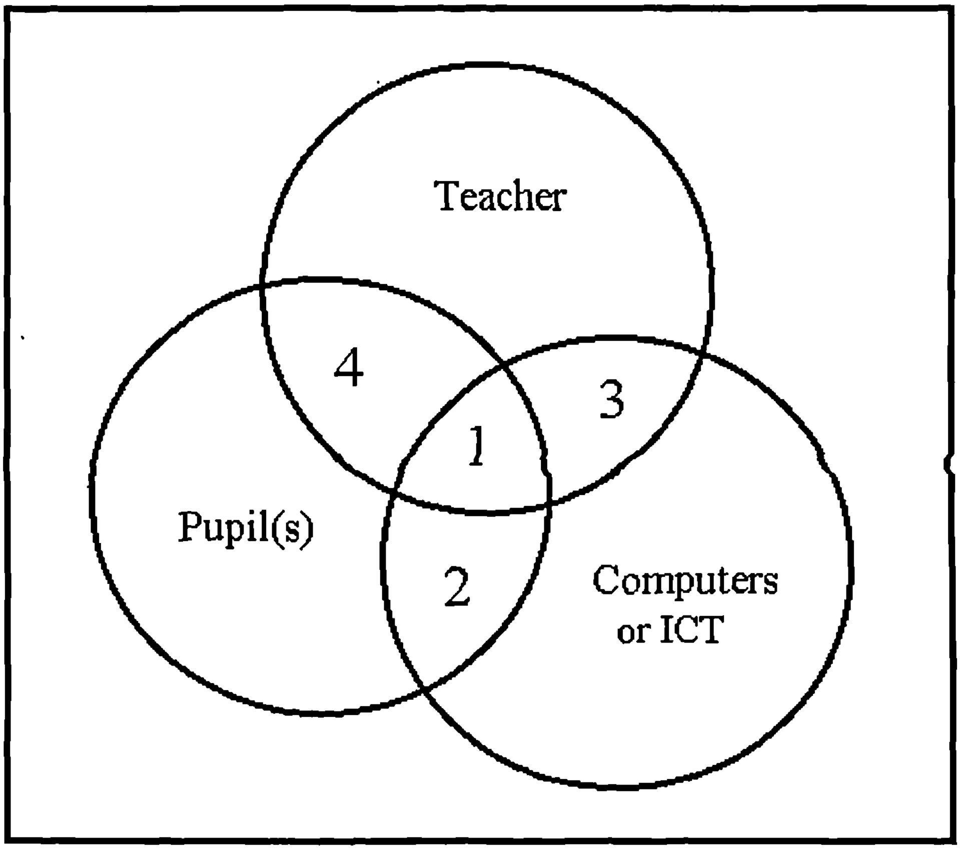
The model suggests that the processing of learning tasks should not go beyond the scope of instructional environment for curricular learning, as expected by the society. For example, in an extreme case, pupils might be highly engaged in learning tasks that lead to undesirable learning outcomes. Similarly, pupils might be highly engaged on a specific computer activity purely for leisure purposes, which does not lead to any desirable learning outcome. According to the rationale of the model, this processing of learning tasks will be classified as unacceptable because they are outside the desirable instructional environment for curricular learning, as expected by society.

In teaching and learning processes, learning outcome is affected by three sources. The first one includes the direct and indirect impacts of teacher behaviour and/or ICT/computer-based/assisted instruction. Teacher behaviour or instructional media can have a direct impact on the assessment and evaluation of the learning product. For example, a pupil's attitudes and behaviour towards an end-of-week test may be different from his/her attitudes and behaviour toward an end-of-year examination. Similarly, parents or teachers might have higher expectations when a child spends a longer duration of time on a computer/ICT-related activity than when the child spends a shorter duration of time on the activity. Pupil characteristics are the second source of influence affecting learning outcomes, including direct and indirect impacts. A pupil with high ability is likely to score higher in a test than a pupil with low ability. The presence of direct relationship is straightforward. Our major interest in this thesis is not on the direct effects of the two sources, but on their indirect effects through the processing of learning tasks. It includes the changes that pupils experience through the processing of learning tasks with or without the use of ICT/computers. In other words, our major interest is in the outcomes resulting from learning, rather than an evaluation of academic achievement that may or may not be related to learning.

In the model, there are three types of feedback/review about learning outcomes. The first one is the feedback/review about learning progress or attainment to the processing of learning tasks. This kind of feedback/review has short-term effects on reinforcing the pupil to engage in the learning tasks, no matter whether computers or ICT are used or not. The second type of feedback/review has direct impact on pupil characteristics. For instance, the notification of high academic attainment or good learning progress will increase the pupil's self-efficacy. In contrast, the notification of low academic attainment or poor learning progress may imply the need for relearning. The third type of feedback/review refers to feedback/review about pupils' learning attainment or learning progress. In the model, the impact of type of feedback/review on teacher characteristics is indirect through teacher perception. In other words, information about pupil learning outcome may have no impact on the characteristics of the teacher if the information is not perceived by the teacher. Nevertheless, change in pupil characteristics can also occur as a result of the pupil's perception of the teacher's characteristics through personal contact, without any behavioural involvement in the learning task(s).

Another characteristic of the proposed model is that it tries to explain teaching and learning without the use of computers/ICT, learning and instruction completely based on computers/ICT and both. In other words, it tries to incorporate traditional teaching and learning, computer/ICT-based instruction and computer/ICT-assisted instruction. The three parties in the teaching and learning processes include the teacher, the pupils and the computer/ICT. An analysis of the inter-relationships between them is presented by the Venn diagram in Illustration I2-2L.

Illustration I2-2L: A Venn diagram showing the inter-relationships between the teacher, pupils and computers/ICT



Remark/Keys: *1* - refers to the interactions between the teacher, pupils and computers/ICT, *2* - refers to the interaction between pupils and computers/ICT, *3* - refers to the interaction between the teacher and computers/ICT, *4* - refers to the interaction between the teacher and pupils.

In the Venn diagram, sector 4 is a unique representation of the traditional teaching and learning activities. A typical example of the interaction between the teacher and the pupils is question and answer activities. In referring to the proposed model, these activities are represented by the component "processing of learning tasks" without the use of computers or ICT in the upper part the model. In the Venn diagram, section 3 is a unique representation of the interaction between teacher and computers/ICT without involving the pupils. Using computers for the teacher's own lesson planning and/or administration purposes can be typical examples of activities of this type. As it does not have any direct impact on learning, it does not refer to any particular component of the model.

In the Venn diagram, sector 2 is a unique representation of the interaction between computers/ICT and pupils without involving the teacher. Some Integrated Learning System (ILS) activities that claim to be designed for pupils' independent learning can be classified as examples of activities of this type. In referring to the proposed model, these activities are represented by the component "processing of learning tasks" with the use of computers or ICT in the lower part of the model. To be specific, they are named as computers/ICT-based activities because teachers are not directly involved. It is different from the interaction between the computers/ICT, pupils and the teacher, which is uniquely presented as sector 1 in the Venn diagram. Examples of activities of this type include the use of computers/ICT for teaching presentation, the teacher using computers/ICT to conduct a collaborative survey of the class, or the pupil's interaction with the computers/ICT with the presence and assistance of the teacher. In referring to the model, they are named as computers/ICT-assisted activities.

The discussion above leads to the conclusion that the components in the model are a detailed representation of the whole mechanism. In some situations, some of the components may not be active. For example, in a traditional teaching and learning environment, only the upper half of the model is relevant. The lower half of the model is not relevant because computers or ICT are not used. To compensate for the weakness, the proposed model suggests readers replace the lower part of the model by a mirror image of the upper part of the model. Similarly, in a pure computers/ICT-based learning environment, the upper half of the model is not relevant. Readers are advised to replace the upper half of the model by a mirror image of the lower part of the model. In other words, the proposed model is perfectly able to describe activities represented in sector 1 of the Venn diagram. A mirror image of the relevant part of the model has to be used to describe activities represented in sector 2 or sector 4.

Finally, communication or interaction has a role to play in the proposed model. First of all, there are two arrows linking the processing of learning tasks with the use of computers/ICT and the processing of learning tasks without the use of computers/ICT. In classroom practice, these effects refer to the contributions of grouping, peer learning as well as the effects of transfer and/or integration between activities with the use of computers/ICT and without the use of computers/ICT. In computer/ICT-assisted activities, the interaction effects at pupil level exist in the transfer and the integration between teaching and learning tasks with the use of computers/ICT and teaching and learning tasks without the use of computers/ICT. To complete a teaching and learning activity, learners may be required to work on learning task(s) with and/or learning task(s) without the use of computers. The interaction effects at group level exist when the computer/ICT group(s) exchange ideas with the non-computer/ICT group(s), and vice versa. The model also suggests the existence of interaction between teacher behaviour and the computer/ICT-based/assisted instruction. In an extreme situation, activities with computers/ICT and activities without computers/ICT may take place simultaneously in the same classroom. It may happen that the teacher interferes with the on-going instruction on the computer/ICT e.g. letting another pair of pupils have a go on the computer/ICT. Alternatively, a pupil on the computer/ICT may interfere with the behaviour of a teacher e.g. asking for help in handling technical or operational problems. So, there are interactions between the two components of teaching and learning. We shall come back to further details about the proposed model in chapter 4 when the model is being used as the framework of investigation of this thesis.

Summary of Chapter 2

- This chapter provides a review of literature, some theoretical models of effective teaching and learning as well as some models concerning the educational use of computers e.g. interaction between instructional system and learner, selection of media. Various aspects of effectiveness are identified from a range of models, which include:
  - Links and the differences between effectiveness at school level, teacher level (i.e. classroom level) and at pupil level.
  - Subject differences e.g. numeracy and literacy.
  - Teacher's beliefs, pedagogic knowledge and practice.
  - The personality of effective teachers.
  - The impacts of teacher behaviour on pupil learning.
  - The effectiveness of various aspects of instruction.
  - The effectiveness of various aspects of the teaching and learning environment.
- The measurement of teaching and learning effectiveness in this thesis includes learning progress (e.g. value-added) and learning attainment. Attention is also paid to the pupils' developed abilities (i.e. verbal and non-verbal), attitude towards learning as well as towards themselves and school learning.
- A model of effective curricular teaching and learning supported by computers or other types of ICT is proposed at the end of the Chapter. It has several unique characteristics:
  - It tries to explain teaching and learning without the use of computers/ICT, learning and instruction completely based on computers/ICT and both (i.e.

computer/ICT-assisted instruction). The integration of ICT activities and non-ICT activities is a factor affecting instructional effectiveness.

- The teaching process is regarded as a stage that starts before the learning process. Teaching begins by the teacher's perception of pupil characteristics and their educational needs. Learning begins when pupil(s) perceive the behavioural actions of the teacher, which includes the instructional context prepared by the teacher.
- The position of the processing of a learning task can be described as an "equilibrium" through various framing and re-framing of the teacher's pedagogy in an applied teaching and learning context. It is determined by the tension between the impacts of teacher behaviour, pupil characteristics and the evaluation of learning outcome. The model suggests that the content of and the way(s) of the processing of the learning tasks lie within the scope of curricular learning and the associated instructional environment, as expected by society.
- The proposed model stresses the role of communication or interaction at pupil level and at group level. It pays attention to the contributions of grouping, peer learning and the effects of transfer and/or integration between activities with the use of computers/ICT and without the use of computers/ICT.

- The key findings of the technical study in the calculation of value-added measures in this thesis are summarised as the table below:

Section	Hypothesis (i.e. It was expected that...)	Result(s) [Further reference]
2-1-4	...there is a link between pupil academic achievement (i.e. maths and reading) and: • the context score, or • the average prior attainment.	[Table T2-1-6] Yes** Yes**
2-1-4	...there is a link between the prior value-added measure and the concurrent value-added measure.	Yes** (+ correlation) [Table T2-1-6]

Keys: ** refers to statistically significant at $p < .01$ level.

Chapter 3

Learning from the perspective of human-computer interaction, in/out-of school learning with computers, subject preference, gender difference and learning effectiveness

The aims of this chapter are to:

- provide a review of contemporary learning theories relevant to the pedagogical use of ICT;
- investigate the inter-relationships between some computer-specific personal characteristics, some other learning-related personal characteristics and learning outcomes, and consider the pedagogical implications in relation to the use of ICT;
- consider some other factors affecting the effectiveness of learning with computers, including:
  - in-school and out-of-school usage of computers;
  - subject preference;
  - grouping; and
  - gender difference.

- A list of the sections in Chapter 3 -

- End of the list -

(3-1) Learning from the perspective of human-computer interaction, effectiveness and the implications for teaching

Introduction

Human-computer interaction (HCI) could be defined as the processes, dialogues, and actions that a user employs to interact with a computer in a given environment (Preece et. al., 1994). The concept has close alignment with, but is slightly different from the focus of this study. This chapter deals with person-computer interaction (PCI). It refers to aspects of personal characteristics that might affect the interaction between the learner and the computer in a given learning environment.

The major purpose of this study is to investigate the effects of three aspects of personal characteristics that are widely thought to be factors affecting the use of computers for learning purposes. The potential impact of some other learning-related personal characteristics on the effectiveness of educational use of computers will be considered. Interaction effects are examined by a series of analyses of variance. Pedagogical implications concerning the use of computers will be included in the discussions.

(3-1-1) A review of learning theories and their pedagogical implications

Before addressing the question about the role of ICT in learning, it is necessary to clarify what learning means to us. To do this, a review of learning theories has been carried out. Among the related literature, Bigge and Shermis (1992) and Hill (1997) were found to be particularly useful. The thesis is backed up by a paradigm of learning theories in line with Bigge and Shermis' work and with reference to other theories in psychology, philosophy, neurology, sociology, cognitive science and in human development. An outline of the major learning theories is presented in a tabular format in Illustration I3-1A.

Illustration I3-1A: Major learning theories described by Bigge and Shermis (1992, page 8-9)

	Theory of Learning I	Psychological System or Outlook II	Conception of Humankind's Moral and Actional Nature III
Mental discipline theories of mind substance family	1. Theistic mental discipline	Faculty psychology	*Bad-active* mind substance continues active until curbed
	2. Humanistic mental discipline	Classical humanism	*Neutral-active* mind substance to be developed through exercise
	3. Natural unfoldment or self-actualization	Romantic naturalism or existential humanism	*Good-active* natural personality to unfold
	4. Apperception or Herbartianism	Structuralism	*Neutral-passive* mind composed of active mental states or ideas
S–R (stimulus-response) conditioning theories of behavioristic family	5. S–R bond	Connectionism	*Neutral-passive* organism with many possible S-R connections
	6. Conditioning with no reinforcement	Classical conditioning	*Neutral-passive* biological organism with innate reflexes
	7. Conditioning through reinforcement	Instrumental conditioning	*Neutral-passive* biological organism with innate reflexes and drive stimuli
Interactionist theories of cognitive family	8. Goal insight	Gestalt psychology or configurationalism	*Neutral-interactive* individual in sequential relationships with environment
	9. Linear cognitive interaction	Social cognitive theory	*Neutral-interactive* purposive person in sequential relationship with environment
	10. Cognitive-field interaction	Field psychology or positive relativism	*Neutral-interactive* person in simultaneous mutual interaction with environment

	Theory of Learning I	Psychological System or Outlook II	Conception of Humankind's Moral and Actional Nature III
Mental discipline theories of mind substance family	1. Theistic mental discipline	Faculty psychology	*Bad-active* mind substance continues active until curbed
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S–R (stimulus-response) conditioning theories of behavioristic family	5. S–R bond	Connectionism	*Neutral-passive* organism with many possible S-R connections
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	9. Linear cognitive interaction	Social cognitive theory	*Neutral-interactive* purposive person in sequential relationship with environment
	10. Cognitive-field interaction	Field psychology or positive relativism	*Neutral-interactive* person in simultaneous mutual interaction with environment

There were similarities and differences between the ways different writers used to classify learning theories. The book written by Hill (1997) summarised learning theories in psychology as belonging to two major paradigms: the Connectionist paradigm and the Cognitive paradigm. The former concerns the connections between stimuli and responses and the resulting changes in experience, while the latter concerns the perceptions, attitudes and beliefs that individuals have about their environment. On the basis of the work by Bigge and Shermis and with reference to the work of other theorists (e.g. Hill, 1997; Joyce, Calhoun and Hopkins, 1997; Schon, 1991; Anderson, 1990; Gardner, 1983; Goleman, 1996; Vygotsky, 1978; Jonassen, 1996; Gagne, 1985; Ausubel, 1968; Piaget, 1963; Sternberg, 1997 and Smith, 1998), learning theories in this thesis can be summarised using three major paradigms: the Mental discipline theories of mind-substance paradigm, the behaviourist and neo-behaviorist paradigm, and the cognitive and social-interactionist paradigm.

The first one regards the mind as a non-physical substance that needs to be strengthened through exercise. Learning theories conforming to this paradigm are concerned with the training or discipline of mind. Intelligent behaviour is the product resulting from the combined work of various faculties of mind, such as perception, memory and reasoning, ...etc. This paradigm includes faculty psychology, classical humanism, self-actualisation theories and structuralism theories. The second one regards learning as a change in observable behaviour. Learning theories conforming with this paradigm are concerned with stimulus substitution and response modification, which includes the formation and operation of stimulus-response bonds, classical conditioning and instrumental conditioning. The third one regards learning as a process for learners to gain understandings of themselves and their environment. During the process, learners act as intentional subjects, and involve themselves in an on-going reciprocal interaction with the environment. The paradigm includes Gestalt psychology, social cognitive theories and cognitive-field interaction theories. The classification of the last two paradigms has integrated some recent learning theories addressed by Hill (1997) into the classification proposed by Bigge and Shermis (1992) e.g. Anderson's information processing theory, Tolman's work on purposive behaviour and learning.

The behaviourist viewed learners as passive receivers of knowledge. Pedagogy driven by this perspective of learning aimed at increasing the strength or the likelihood of occurrence of the target behaviour. Instructional arrangements made use of environmental agents that were known to be associated with the occurrence of the target behaviour. They would be used as stimuli to trigger or reinforce the probability of the target response.

Later, behaviourist theories were integrated with knowledge gained from cognitive psychology and information processing theory. The variations of behaviourist theories gave birth to neo-behaviourism, which used human behaviour as the source of data, but also allowed for the use of unobservable and covert processes as explanatory devices. Traditional behaviourism assumes that a person's psychological environment and physical environment are identical. In contrast, cognitivist and social-interactionist views a person's environment as being psychological, while physical environment is only a part of it. Besides physical attributes of the psychological environment, cognitive paradigm theories are also concerned with other relevant non-physical attributes of the environment. For instance, memories and expectations are attributes that operate at an imaginary state, but not at a physical state. Unlike traditional behaviourists, neo-behaviourists accept the influence of other non-physical attributes of the psychological environment on human behaviour.

Information processing theory was first formally proposed by Atkinson and Shiffrin (1968) and was extended by Anderson (1990, 1993). The learning theory linked the work of neutrons in human brain to the way computer chips work in processing information. It was held that knowledge about things or events had many attributes. For instance, the attributes of an apple may include its size, shape, colour, taste, value, hardness, durability,...etc. These attributes can be regarded as features about the apple, which make it a unique object to the person. The knowledge is stored in a memory section inside the brain on a short-term basis. As the capacity of the short-term memory is very limited, most of the information has to be transferred to the long-term memory through a coding process. The knowledge database is formed by lots of factual and procedural information stored in the long-term memory. When knowledge about a certain thing or event is needed, relevant information about it will be retrieved from the long-term memory to working memory through a decoding process.

The effectiveness of retrieval is greatly affected by the way the old information within the brain is classified and the way new information is stored. In Piaget's terms (e.g. 1963), there are two common ways - assimilation and accommodation. The former refers to the process of adding new information to existing categories of knowledge, while the latter refers to the process of creating a new category or sub-category of knowledge so as to fit in the new information. With the assumption that the knowledge database is hierarchical in structure, the knowledge of an educated or experienced person is expected to be different from that of an uneducated or inexperienced person in terms of the breadth and depth of the knowledge database. In Biggs and Collis' (1982) terms, their knowledge database differs in terms of the complexity of the networks of links between learnt concepts, starting from the simplest "unistructural" to "multistructural" to "relational" to the most complex "extended abstract" structure. That means that, when being asked to recall what they know about a certain thing, an educated or experienced person will be able to retrieve more attributes of the thing or event than an uneducated or inexperienced person. Attributes about apples are clear to an educated or experienced person (e.g. experience about apples or in the fruit industry), hence, retrieval of the conceptions about apples is more accurate or even faster. For example, the recall of an apple may begin with its name, and then its size, shape, colour,..., and so on. The process is somewhat like the spread of a drop of ink on a piece of paper. As the processes involve making information related to the concept active in short-term memory to be used in the thinking processes, it is named "activation". Information not being active in short term memory will be lost gradually. This is known as the process of "forgetting".

Besides factual information, the knowledge database also contains procedural information. However, the generalisations or understandings are explanatory in nature because knowledge is viewed as absolute or as the universal truth. That means learners know some principles by which the facts are inter-related. Two pedagogical approaches are driven by the theory. These include:

1. a hierarchical "bottom-up approach" which focuses on teaching the sequence of skills starting from low-order skills to higher-order skills, as proposed by Gagne (1985), and
2. an overview of the learning content arrangement or "advance organisers", as proposed by Ausubel (1968).

Traditional cognitive theories are also enriched by ideas of social-interaction theories. Learners play an active role in solving real-life, practical problems. The learner's motivation, expectation and the capability to transfer learnt knowledge to new situations affect the effectiveness of learning. A crucial determinant of the effectiveness of learning is anchored on the basis of "authenticity" of the learning activities. That means, the context of learning has to be relevant or meaningful to the learner's own experience. Learning becomes a process of integrating new experience into the learner's existing knowledge database. The knowledge content or structure is subjected to on-going constructions and reconstructions through the processes of gaining or changing insights, outlooks, expectations, or thought patterns. Bigge and Shermis (1992, page 311) describes the major characteristic as "learning at reflective level", which involves "careful critical examination of an idea or supposed article of knowledge in light of the empirical, testable evidence that supports it and the further conclusions toward which it points". As knowledge is viewed as dynamic rather than absolute, generalisations or understandings are exploratory in nature. Pedagogy driven by this perspective will consider ways of facilitating learners to increase their knowledge database with more tested understandings as well as empowering learners with the ability to solve problems on their own.

Learning theories and pedagogical use of ICT

"How can advances in research on human cognition, development and learning be incorporated into educational practice?" is the first among the four topics of research work set by the NRC in the United State (National Research Council, 1999c). With an interest of putting theories into practice, the text below will focus on the relationship between learning theories and the ways of using computers in daily classroom practice.

Attention to the educational use of computers of this thesis is not focused on mental discipline theories of mind-substance paradigm. Bigge and Shermis (1992, page 309) stated that both faculty psychologists and self-actualisation theorists were not supportive of the use of computers and the majority of classical humanists had negative attitudes toward a wide range of educational technology. They thought that the central issue in the use of computers was between the behaviourist perspective (i.e. including neo-behaviourist theories) and the cognitive and social-interactionist perspective.

The evolution of learning theories has close alignment with changes in the pattern of computer usage in education. Most of the computer use in 1960s and 1980s were based on the behaviourist and neo-behaviourist perspective. Computers were used as a provider of feedback and as a positive reinforcement agent for appropriate responses. "Programmed instruction" was the principal pedagogy (Romiszowski, 1988), in which learning materials were presented as a sequence of activities arranged in a hierarchy. Most computer activities took place in various forms of "drill and practice". In application to learning and teaching processes in the classroom, the role of computers was mainly as deliverers of curriculum content. Drill and practice exercises and computer-based tutorials were typical examples of this type of activity. Computer learning environment was mainly characterised by repetitive practice, learning by rote (Soloman, 1986, page 8) and training in technology.

Learning theories from cognitive and social-interactionist perspectives regard learning as a result of the interaction between the learner and the learning environment. Learners have to play an active role in the on-going process of constructing, organising and reconstructing knowledge of their own. Features of computers nowadays have a great potential for making contributions to the interaction. In the text below, the author of this thesis would like to mention three theoretical notions that outline the reasons leading to an effective use of computers (or other forms of ICT) in learning and teaching.

The first notion is "mindtools". These are computer applications that engage or facilitate learners in thinking. Logo was the first mindtool (more appropriately named "quasi-mindtool", refer to the text below) formally used in the classroom. It was a computer programming language specially designed for children by Papert during the 1980s and it is still being used in many schools. Often children are required to make use of the programming language to solve a particular problem, such as instructing an electronic "turtle" to move in a particular way. In the computer activity, children have to play an active role in engaging themselves with a mechanised version of thinking. Children can pose and test out the "powerful ideas" concerning the rules for the actions that they have generated. The control technology not only develops children's rational thinking required for programming, but also helps them understand geometric and logical relationships. Generalisations or understandings discovered from the learning activity are explanatory in nature. The appropriateness of the acquired knowledge is absolute, rather than relative.

For Jonassen (1996), computer programming and Papert's microworlds were "quasi-mindtools", a mindtool which is even more powerful. They have some features of mindtools, such as the capacity to engage learners in critical thinking and to facilitate the transfer from computer-based/assisted learning to other types of problem solving. They were named "quasi-mindtools" because they met all the criteria for mindtools and had the unique feature of allowing the learners to define their own problem to solve and use the tools for exploration in the simulation of real-world phenomena. The contributions of microworld are not only restricted to the construction of knowledge representations, but also engaging learners in problem solving.

Jonassen defined "mindtools" as technology-based tools through which learning environments are adapted or developed to function as intellectual "partners" with the learner in assembling and constructing knowledge of their own. According to his definition, mindtools require the learner's mindful engagement in the learning process. A learner's input enhances the capabilities of the computer, and the computer enhances the learner's thinking and learning. He thought the outcome of using mindtools was critical thinking, which was the skill of thinking about the learning content in different ways. Mindtools actively engage learners in the creation of knowledge that reflects their comprehension and conception of the information rather than focusing on the presentation of objective knowledge (Jonassen, 1996). As knowledge becomes a subject for on-going changes, learning with this type of "mindtool" is at exploratory-understanding level. For example, a learner may carry out a keyword search from an electronic thesaurus, an electronic dictionary, the internet or from an encyclopaedia on a CD-ROM. The results can be compared with the ideas that he has noted down during a brainstorming exercise. This way of using the "hypertext" feature of the computer functions as a referencing system for knowledge acquisition and refinement. With reference to Anderson's theory, this kind of exercise would help in the construction or reconstruction of the learner's knowledge content and structure. The tools are used as an aid for investigation or reflection. There is also a range of computer applications designed to facilitate the development of insights and knowledge structure available in the market. For instance, Pollard's (1997) summary of reflective teaching practice is presented as a concept map in Chapter 5 Illustration I5-1H, which was drawn with the use of computer software application of this type.

The second notion is the "zone of proximal development" proposed by Vygotsky (1978), who can be classified as a social-interactionist. He distinguished the actual developmental level from the level of potential development of a child under the guidance or facilitation of any helper, such as an adult or a peer. The gap between the two levels was an optimal zone of development for the child because helpers could enable the child to reach the attainable level of development by helping the learners to construct the key framework of knowledge of their own at a higher level. The process of facilitation in learning was called "scaffolding". When applying the concept to the use of computers (or some other types of ICT e.g. calculators, spell-checkers, concept keyboards) in learning and teaching, features of the computer have enabled it to function as an electronic helper. With proper instructional design and resources, the computer can provide curriculum activities on an individualised basis. This creates a learning environment in which tasks are set at a challenging but realistic level for individual learners. Furthermore, the computer can also function as a stimulus as well as a means of communication between the learner and teacher and between learners.

The third notion is the theory of "multiple intelligence" proposed by Gardner (1983). He pointed out that traditional tests of intelligence failed to describe the full extent of intelligence of human beings. Traditional tests, such as verbal reasoning tests, maths and English tests, were good at describing specific aspects of intelligence, but they were too narrow to cover each of the key areas of intelligence. In line with this, Goleman (1996) added that emotional intelligence was also a key factor affecting ability, which had been neglected in traditional models of human ability. In the book "Frames of Mind", Gardner (1983) proposed a model of "multiple intelligence", which consisted of seven dimensions of intelligence. The concept was extended to eight dimensions in his later books (e.g. Gardner, Kornhaber and Wake 1996; Gardner, 1999), which included:

1. Verbal or linguistic intelligence: The ability to use words
2. Logical-mathematical intelligence: The ability to reason logically, solve number number problems
3. Visual-spatial intelligence: The ability to form mental images or pictures, and to find your way around the environment
4. Musical intelligence: The ability to perceive and create tone, rhythm and timbre

5. Bodily-kinaesthetic intelligence: The ability to carry our motor movement of the whole body and the limbs
6. Interpersonal intelligence: The ability to understand other people
7. Intrapersonal intelligence: The ability to understand yourself and develop a sense of your own identity
8. Naturalist intelligence: The ability to recognise and classify the numerous species of his or her environment (Remark: It was included in 1999)

(Adapted from: Gardner, 1999, page 41-44 and Leask & Meadows, 2000, page 8)

The last dimension is still a controversial issue. The author personally think "spiritual intelligence" should be included and it could be appropriate to describe this dimension in words such as "moral intelligence". The alternative terminology was certainly rejected by Gardner (1999) who thought that morality was about personality, which was about human nature, rather than intelligence.

Features of ICT, such as the multimedia function of computers, provide a rich source of information for learning with different forms of representation. ICT activities can provide multi-sensory stimulation for learners. Sensory information presented before the introduction of main content can be used as an "advance organiser" which facilitates learning, as proposed by Ausubel (1968). For example, the introduction of diagrams might help pupils to understand the mechanism of mathematical operations.

In introducing the idea of "accelerated learning" with ideas about how human brain works, Smith (1998) stressed that input of new information should utilise visual, auditory and kinesthetic modes. If the sensory inputs are sufficiently distinctive, the information will gain access to long-term memory. This implies that the multi-sensory nature of information input presented by the computer will be particularly effective to suit learners with wide range of visual-spatial or linguistic ability. For example, one might expect learners who are weak at creating an imaginary visual picture of the auditory inputs they have received might benefit from audio-visual presentations, with sound, pictures and/or diagrams. Additional sensory inputs of the thing or event may help the registration of presented content in long-term memory.

Nevertheless, Gardner (1987) thought that there were differences in cognitive style between individuals. The differences occur in the perception, thinking, problem-solving and memory processes between individuals. For example, an individual may prefer processing in visual mode to processing in audio mode. In relation to the application of ICT to support effective learning and teaching, cognitive styles and learning styles is a fundamental pedagogical issue to be considered. The present study extends the investigations with other selected aspects of personal characteristics, including some computer-specific characteristics and general learning-related characteristics. It will examine the interaction effects between the characteristics.

Further to the proposed metaphors, we are still unsure whether lay people think in accordance with such dimensions or models. Lay people notice that an intelligent person has the ability to solve problems well, to reason clearly, to think logically. The person also has a large collection of information and is able to balance information in practical and academic contexts (Furnham, 2000). With respect to lay theories of intelligence, Sternberg (1997) did an excellent critical and taxonomic job in classifying intelligence under seven academic metaphors as below:

1. Geographic: It seeks to map the mind and understand the structure of intelligence.
2. Computational: It seeks to understand information-processing programmes and processes underlying intelligence.
3. Biological: It asks how the anatomy, physiology and chemistry of the brain and central nervous system accounts for intelligent thought through hemispheric localisation and neural transmission.
4. Epistemological: It asks what are the structures of the mind through which all knowledge and mental processes are organised.
5. Anthropological: It asks what form intelligence takes as a cultural invention, may be comparative and relativistic. For example, why does one culture believe certain behaviours are part of intelligence while another does not?
6. Sociological: It examines how social pressures (mediated learning experiences) in development are internalised. Metaphors focus on different types of intelligence (i.e. multiple intelligences) and how they relate to one another.
7. Systems: It is concerned with how we understand the mind as a system, which cross-cuts metaphors.

(From: Sternberg, 1997 and Furnham, 2000)

To equip themselves with the ability to solve problems of the real world, learners need to acquire and to combine intelligence derived from the above academic disciplines. Interestingly, features of modern computers greatly facilitate the implementation of an integrated curriculum. In relation to the conceptions of "multiple intelligences" or "academic metaphors of intelligence", we also have to bear in mind that the whole is more than the sum of the parts. Educators should not only work on promoting each of these dimensions or academic metaphors of intelligence, but the whole intelligence(s) behind these conceptions. For instance, in referring to the primary curriculum, we might expect an increase in the efficiency in learning if a suitable music background is given to children when they are at work. There are potential benefits in integrating the teaching of academic subjects with music, art, civic education and/or physical education. With proper instructional design and ICT resources, computers can facilitate the presentation and delivery of an integrated curriculum. The learning outcomes could extend from cognitive to social and emotional domains. This dimension of usage of computers in education gives supports to the rationale of "whole-person education".

(3-1-2) Personal characteristics and learning

Different people may not learn equally well in different learning environments (e.g. Howe, 1998; Newton, 2000). It might be reasonable to expect that the effectiveness of computer supported learning environments in primary classrooms differs between different types of learner. There is a need to think about the characteristics of pupils before considering issues about pedagogical planning and practices concerning the use of ICT. The present study had made attempts to classify pupils into various types or groups, according to their personal characteristics. The selection procedure began with the consideration of some personal characteristics widely thought of as related to computers, which are called "ICT-specific" variables in the study. Three computer-specific variables were selected for the study. They were:

- concentration when learning with computers,
- self-rated competence in using computers, and
- attitude towards software interactivity.

Reference was also made to published lists of categories and sub-categories of individual differences related to learning (e.g. Busato et. al., 1998; Riding & Rayner, 1998; Ayersmam & von-Minden, 1995; Jonassen & Grabowski, 1993; Weinstein & Alexander, 1988). Due to the amount of time available, there was a need to narrow down the focus of interest to a list of selected variables. The major criterion used in the selection procedure was to choose some variables that appeared to be related to educational performance (e.g. Kolb, 1985; Ayersman & von-Minden, 1995; Creemers, 1994; Biggs, 1987b; McClelland, 1961; Bracken, 1992; Attenborough, 1993). The variable selection was also influenced by the investigator's experience, interest and preference. Here is a list of the general learning-related variables selected for this study:

- concrete experience orientation of learning,
- reflective observation orientation of learning,
- abstract conceptualisation orientation of learning,
- active experimentation orientation of learning,
- (perception of) teacher-pupil relations,
- surface learning motivation,
- deep learning motivation,
- achieving learning motivation,
- concentration (in learning),

- academic self-concept (in general),
- self-concept in numeracy work,
- self-concept in literacy work,
- self-concept in school work and learning,
- social self-concept, and
- time management

These variables are called "general learning-related" variables because they do not seem to have a direct link with computers. The label implies the possibility of having an indirect relation with computers, which are the focus of the investigation. Some of the variables were further divided into sub-types, according to the classifications described in the specific measuring instruments. It might be good to note that they cover several major dimensions of learning: cognitive, meta-cognitive, social and emotional dimensions of learning. We shall briefly review the literature concerning each of these variables and suggest some possible links with the effectiveness of using the computers in the text below.

Awareness of the relationship between learners' characteristics and their pedagogical needs is a fundamental step for effective pedagogical practice. If the target pupils share a common characteristic in learning, teachers and instructional designers can make the best use of their strengths and provide support for their weaknesses. For example, given that the target pupils are quite competent in IT, teachers may allow them to access the computers without detailed explanations about the operational skills required for completing the tasks. Generally speaking, instructional arrangements tend to be suitable for pupils with a wide range of personal characteristics, especially when the size of the target group is large or when pupils come from diverse backgrounds.

Special educational needs, ability to learn and educational use of computers

The issue of special educational needs (SEN) is treated as an integral part of a spectrum of personal characteristics in medical and health-related professions. These include...

- physical impairment,
- sensory impairment (i.e. visual & hearing),
- language and communication disorders (speech),
- emotional and behavioural disorders,
- specific learning difficulties, and
- cognitive impairment.

In the field of education, it might not be necessary nor appropriate, to distinguish pupils with SEN from their peers. With proper teacher training and with extra resources, the computer-supported learning experience of pupils with SEN may not significantly differ from the experience of their non-special-needs peers (e.g. Goler, 1990). Depending on the nature of special educational needs, the use of computers can enable some pupils with SEN to learn as well as their peers. In contrast, some pupils with SEN are greatly hindered by the knowledge and skills required in using computers. The criteria for classification can be illustrated by a statement in a recent report concerning the use of information technology and special educational needs as below:

"Pupils with physical disabilities and those who were dependent on information technology to access the curriculum were generally able to use it independently, with relatively little input from the class teacher or other pupils in the class. However, this was not the case for some of the pupils with learning difficulties, who required substantial input from others to be able to use the information technology effectively." (Brooks, 1998, p.37)

The illustration above implies the need to classify pupils with special educational needs into two groups, in relation to their ability to use computers. Pupils with hearing difficulty may benefit from the adjustment of the volume on the computer or the use of hearing aids. With proper accessing devices, their ability to learn does not differ from other able peers. In contrast, pupils with learning difficulties may have difficulty operating the computer on their own.

To make pedagogical decisions concerning the effective use of ICT for curricular learning, the focus of attention is pupils' ability to operate the computer, rather than the types of difficulty in accessing to the subject content on the computer.

Learning style and the use of computers

In a recent literature review on individual differences with computers and instruction, Ayersman and von-Minden (1995) recommended that "the use of the computer as an instructional tool and its relationship to research on individual styles of learning appears to be an area holding great promise". Riding and Rayner (1998) further suggested that possible research areas included "the fundamental nature of style, and the interaction between style and other behaviour influences". These suggested that it is valuable and timely to study the relationship between learning style (i.e. in a wider context) and the use of computers, as well as their interaction with other variables.

Learning style in a wider scope: cognitive and personality variables

Soloman (1992) proposed four dimensions of learning style. These dimensions were processing (active/reflective), perception (sensing/intuitive), input (visual/verbal) and understanding (sequential/global). Montgomery (1995) pointed out that individual differences in learning style have been typically ignored in traditional teaching approaches. She further demonstrated the effectiveness of multimedia in addressing the diversity of learning styles of 143 chemical engineering students. A multimedia-based software application was used to teach the concepts, units and type of equipment for measuring pressure and temperature. The effectiveness of the software application was evaluated by questionnaire completed by students. It was concluded that:

"

- sensors benefited from additional reviews of abstract material and appreciate the demonstrations,
- active learners appreciated the use of movies and interaction,

- visual students appreciated the movies as well as the visual navigation scheme, and
- global learners preferred placing the new material within greater context.

(Montgomery, 1995)"

Links between learning style and the effective use of computers in education have been found by some other academics in the area, although their scope and definitions of "learning styles" are different from one to another. Riding and Rayner (1998) reviewed evidence for the validity of style differences in learning and suggested that the design of integrated learning systems needed "an executive control" to work on the student's cognitive style. These would include:

"

- the initial assessment of student knowledge necessary to give understanding to the new topic, and
- the controlling of aspects of presentation to facilitate ease of learning and to reduce information load by taking account of the student's learning style and intelligence, in terms of:
  - conceptual structure (the need for an organiser or an overview)
  - type of content, (visual or verbal)
  - layout of information (e.g. tables, tree diagrams, etc.)
  - choice of mode of presentation (words or pictures)

(Riding and Rayner, 1998, p.184)"

Tymms and Gallacher (1995) further evaluated the effects of cognitive styles in relation to pupils' value-added scores. Riding's Cognitive Styles Assessment (CSA) was administered to 52 Year 6 children and 18 teachers (Riding, 1991). The focus was placed on the match or mismatch between teachers' cognitive style and pupils' cognitive style. The results did not give support to the validation of the expected effects as a result of the mismatch between the cognitive styles of the pupils and teachers, in terms of pupils' value-added scores.

It is obvious that conceptions of "learning styles" vary between academics in this area. There are similarities and differences between terminologies describing the construct, such as cognitive styles, learning approaches, learning strategies, processing strategies, learning orientations, metacognition...etc. Some academics also pay special attention to the validity of style differences among learners of different ages (e.g. Biggs, 1992; Kolb, 1984). Kolb's experiential learning theory typically regarded the longitudinal change in learning style as a developmental process. Academics also made attempts to summarize and resolve conflicting issues between different schools of thought about learning styles. Reasonable success and common ground have been proposed by some authors in this area (e.g. Busato et. al., 1998; Ayersman and von-Minden, 1995; Biggs, 1993a & 1993c; Riding & Cheema, 1991). The work of Vermunt (1992) proposed four different learning styles. These include meaning directed, reproduction directed, application directed, and undirected. Busato et. al. (1998) further examined these learning styles in higher education. The authors concluded that undirected and reproduction learning styles were found to have a greater importance in early years of higher education than in later years, while meaning directed and application directed learning styles were found to have a greater importance in later years than the early years. The results of this study implied that different learning styles might be preferred at different stages of learning and development. Please also note that there are also differences between the scope of "learning style" defined by different authors.

In reviewing the relations between individual differences, computers and instruction, Ayersman and von-Minden made reference to aspects of individual differences proposed by Jonassen and Grabowski (1993). They made decisions on selecting some of the aspects that were related to computers. The selected variables could be reported as the four categories below:

- Cognitive controls e.g. field dependence/independence, cognitive flexibility
- Cognitive styles e.g. visual/haptic, visualizer/verbalizer, serialist/holist, analytical/relational
- Learning styles e.g. Kolb's learning styles
- Personality types e.g. locus of control, extroversion and introversion

A broad definition of learning style might include cognitive and personality preferences that are linked with the way information is processed by an individual. The conceptions of cognitive style and learning style are often intermingled together or mixed up in some studies concerning learning style. The former refers to an individual's preferred and habitual approach to organising and presenting information (Riding and Rayner, 1998). The latter refers to the characteristic behaviours of an individual that serve as relatively stable indicator of how the individual perceive, interact with and respond to the learning environment (Keefe, 1979). The primary interest of this aspect of study is focused on the latter. Interestingly, among other learning styles sub-categories listed by Ayersman and von-Minden's, Kolb's learning style was the only sub-category they selected for their study. Their selection also meant their acceptance of the potential links between Kolb's conception of learning style, computers and instruction.

Learning style measures in this study

In line with Ayersman and von-Minden's choice, this study tries to narrow the scope within Kolb's (1985) theory of "learning style". He classified four orientations according to learners' preference in perception and processing. He proposed that there were two contrasting modes of perceptions - concrete experience and abstract conceptualisation. Learners using the former style are used to perceiving things by sensations (e.g. feeling, touching, seeing, and hearing), while learners of the latter style are used to perceiving things by mental or visual conceptualisation. There were also two contrasting modes of processing - reflective observation and active experimentation. Learners of the former style are used to thinking about things, while learners of the latter style are used to doing things with the information. Detailed discussion about learning styles and development can be found in Chapter 5.

Instead of working towards a comprehensive view about learning style, the present study restricts the definition of "learning styles" to the constructs measured by Kolb's Learning Style Inventory 1985 (LSI-1985). In other words, its meaning is limited and supported by the Experiential Learning Theory. There are three major reasons for the decision.

Firstly, recent definitions of learning style have been formulated by synthesising different theoretical work in this area. The scope is so broad that no existing measuring instrument of learning style is found to be satisfactory. By narrowing the scope of "learning style" on the basis of an established learning theory, learning style measures used in this study became theoretically clear. Secondly, by narrowing the scope, selected additional features of learning style could be addressed as independent variables in this study. For instance, part of Bigg's Study Process Questionnaire was used as measures of "learning motivation" variables. Thirdly, Kolb's experiential learning theory incorporates the work of Dewey, Lewin and Piaget. It is compatible with many recent models and theories about learning and professional development, as it shares some of the features of constructivism, problem-based learning, reflective learning and perspective transformation. For details about the scope of learning theory, please refer to the literature review in Chapter 5.

There is evidence suggesting that the LSI-1985 is widely used in adult and higher education (see Kolb, 1984), but it is rarely used in primary education. This could be due to the fact that its standardisation was carried out with samples aged from 18 to 60. People might have assumed that the instrument was originally designed for adults, but not for children. However, that assumption may be queried on the following grounds:

- There is no evidence suggesting that it is not valid in primary education, although the experiential learning theory is based on Dewey's work in adult and higher education.

- It is obvious that children at the age of primary education also learn from correcting misconceptions or biased assumptions. So, reflection and perspective transformation also take place among young children. We should not ignore the value of the transformative dimension of learning simply because of the technical difficulty of assessing young children.
- Most of the words that the LSI-1985 used are simple enough for children at primary education to understand. With adaptations and careful item selection, it could be feasible to administer the instrument to children in primary education.

For these reasons, it was expected to be useful to try the idea out with children in primary education. It is good to note that Kolb's theory is the common area of some of the literature about learning styles, as outlined by Montgomery (1995), Busato et. al. (1998), Ayersman and von-Minden (1995), Soloman (1992) and Vermunt (1992). To be specific about its relations with the use of computers, it might be rational to infer that:

- sensors, who are high in the concrete experience orientation of perception, appreciate demonstration and presentations by computers;
- reflectors, who are high in the reflective observation orientation of processing, value time gaps between their interactions with computers for linking new information with their prior knowledge;
- intuitive learners, who are high in the abstract conceptualisation orientation of perception, appreciate the use of computers as mindtools; and
- active learners, who are high in the active experimentation orientation of processing, value the interaction with computers.

So far, it might be worthwhile to note that each of these orientations to learning is a form of preference or strategy for processing information. As Wood (1998a) pointed out that availability of processing strategies has a close relation with the development of the child, it is reasonable to speculate that the relationships between the four orientations above and learning outcomes are positive in nature. As it is possible that pupils with different learning styles can benefit from the educational features of the computers, it is reasonable to expect that the relationships between each of the four orientations above and each of the three computer-specific variables will be positive in nature.

The measures concerning learning styles are presented below. In each of the items below there are four measures. The first measure refers to concrete experience orientation (LSA). The second measure refers to reflective observation orientation (LSB). The third measure refers to abstract conceptualization orientation (LSC) and the forth measure refers to active experimentation orientation (LSD.)

Here are some examples of the items measuring learning styles (Source: Kolb, 1985):

1. When I learn:

a) I like to deal with my feelings.

b) I like to watch and listen.

c) I like to think about ideas.

d) I like to be doing things.

2. I learn by:

a) Feeling.

b) Watching.

c) Thinking.

d) Doing.

Please refer to LSI-1985 for the details
about the content of the instrument

Remark: Each of the items a) above is a measure of concrete experience learning orientation (LSA), each of the items b) above is a measure of reflective observation learning orientation (LSB), each of the items c) above is a measure of abstract conceptualization learning orientation (LSC) and each of the items d) above is a measure of active experimentation learning orientation (LSD), as described in Kolb's experiential learning theory (Kolb, 1984) and Learning Style Inventory - 1985 (Kolb, 1985).

Learning motives, concentration, self-esteem and the use of computers

There is a close relation between learning styles and learning motives. For example, Biggs (1987a, 1992, 1993c) differentiated learning approaches into two major orientations: learning motives and learning strategies. The former refers to the social and emotional aspect of learning, while the latter refers to the cognitive and meta-cognitive aspects of learning. Motivation is a state of arousal leading to behaviour. It helps a person work towards a specific direction of a life goal. Its maintenance function keeps the behaviour in a relatively stable condition. Although motivation make contributions to concentration in learning, there are other variables that have an impact on concentration in learning. For instance, a highly motivated child might fail to concentrate in learning if the learning environment is too insecure, cold, noisy...etc. This is the reason why measures concerning concentration in learning and measures concerning learning motivations are treated as independent measures.

As a natural skill to adapt to the world in which they live, children are generally curious towards the things and events they perceive. However, curiosity is sometimes non-directional and temporary. It is different from motivation, which works in a specified direction. Human motives aim at various aspects of life, so there are different classifications of motivation. In relation to the focus of this thesis, this section is targeted at motivation in learning.

Learning theories conforming to different paradigms have different accounts of learning motives. Prominent psychologists who investigated learning motivation from a behaviourist perspective include Thorndike, Skinner and Hull. They worked on the use of rewards to increase the frequency or intensity of desirable behaviour, and the use of punishment to decrease the frequency and intensity of undesirable behaviour. That means, learning behaviour that brings satisfaction will be encouraged, while learning behaviour that results in discomfort will be discouraged. The interactive, speedy and automatic features of the computer can facilitate the provision of positive and negative feedback. It can function as a reliable reinforcement agent in giving the right response for behaviour. Immediate feedback makes learning effective because correct answers will be given by either the pupil or by the computer before the learning content fades from memory. It fosters a strong association between target behaviour and reward.

Many psychologists disagreed with behaviourists' theory about learning motives. They pointed out that behaviourism is grounded on the impact of physiological needs. For human beings, there are motives other than motives originating from physiological needs. Maslow was a prominent psychologist who held this belief. He investigated learning motives from the mind substance perspective. He proposed that there is a "hierarchy of needs". It consists of seven levels. Here is the list of them starting from the lowest to the highest: physiological, safety, love and belonging, esteem, self-actualisation, knowledge and understanding, aesthetic. Needs at a higher level will not become prominent unless needs of a lower level have been fulfilled. Food, water, rest are physiological needs. Unlike behaviourists, Maslow thought that motives based on physiological needs occur only in extreme conditions, such as starvation or extreme thirst. In normal circumstances, human beings are often in pursuit of needs at a higher level.

Maslow's theory has made a contribution to learning and teaching. It reminds us of the potential bias that results from focusing on a specific type of need. Teachers have to provide a learning environment that can fulfill pupils' need for safety and care. These are foundations for building esteem. Without the fulfilment of self-esteem, the motivation towards fulfilling targets of life or exploiting self-potential is weak. So, the identification of pupils' needs is an essential starting point. Teachers have to support pupils in fulfilling their needs. Having said that, teachers should not neglect to encourage pupils to pursue needs at a higher level. In relation to the use of computers in primary classrooms, teachers have the duty of providing pupils with reliable hardware, software and other learning resources. Insecurity resulting from computer operations - such as frequent technical failure, should be avoided. More importantly, teachers should encourage pupils to work on subject content with the computer, rather than putting too much attention on the technical features of the learning tool. The interactive, speedy and automatic features of the computers can also alleviate teachers' burdens in record keeping and facilitate the delivery of lesson content and instruction.

Learning theorists taking a cognitive and social-interaction perspective have taken on some features of theories of the two perspectives above. As with behaviourism, cognitivist theorists emphasise the impact of environment on learning behaviour. They also pay attention to mental operations, as suggested by theorists in the mind substance tradition. Some cognitive theorists extend the work on external stimulus originating from behaviorism with ideas from cognitive and social psychology. For example, Bandura's social learning theory (1977) proposed that social models have significant impact on learning. If a modelled behaviour is rewarded, it will reoccur.

On the contrary, the behaviour will diminish if the social model of the behaviour is penalised. To take an example of using ICT, presenting a video about the success of a child in a running race may motivate pupils to practice running techniques in their physical education lesson as a form of imitation. They may feel more confident about winning a running event if they substitute themselves as the presented character. As the successful experience of the child becomes a positive experience for them, it becomes a form of motivation.

Some cognitive theorists focused on the psychological needs and the cognitive processes of the learner. Some psychologists worked on the arousal function of motivation. They discussed how human attention spontaneously operates as an adjustment to stimuli. Sometimes, learners have to select certain tasks, rather than others. There are different theories explaining the mechanism. These include a filter approach proposed by Broadbent (1958) and an effort-reduction approach proposed by Kahneman (1973). Psychologists in this field thought that gaining pupils' attention is an important starting point in learning and teaching processes. In a primary classroom setting, pupils are influenced by various stimuli they perceive, such as the teacher, other pupils, books, the computer, or some other things and events. Pupils also have different expectations and needs. Their attention is 'selective'. It means that they tend to attend to things or events that are relatively strong in drawing their attention and tend to neglect those that are relatively weak. It is the teachers' duty to make the lesson content more interesting to pupils than other stimuli in the classroom. Modern computers are strong in drawing pupils' attention by attractive modes of presentation. The range of information that a computer can provide includes audio, and visual material. The capacity of information that it can provide is also huge.

Nevertheless, we should note that successful learning sometimes require pupils' on-going attention throughout the learning process. In other words, they need concentration. There is research evidence to suggest that children working on the computer have higher motivation and better concentration (e.g. Keyes, 1994; Watson, 1993; Moore et. al., 1993).

McClelland was another psychologist who investigated the effects of motivation. He claimed that people around the world share the motive to achieve. He thought this was the essential characteristic for success (McClelland, 1961). However, the limitation of the theory was that not all people who have a strong achievement motivation can successfully reach the performance target of being successful. Atkinson, one of his research partners, extended the theory. He proposed that the performance of an individual was determined by (refer to Atkinson, 1980 & Atkinson and Raynor, 1974):

- his motive to succeed and to avoid failure,
- the probability of his success and failure, and
- his incentive to succeed and to avoid failure.

Atkinson thought that people with high achievement motivation would not mind too much about failure, however, people with low achievement motivation would. People with high achievement motivation like tasks of moderate difficulty, rather than tasks that are too easy or too hard to achieve. In relation to the capacity of memory and the interactive features of the computer, learning tasks can be set at a challenging, but realistic, level. Computer-managed instruction (CMI), integrated learning system

(ILS) and expert systems are practical examples of this type of computer use. It may be reasonable to speculate that learners with high achievement motivation benefit more from the automatic record-keeping and instructional planning features provided by the computers than learners with low achievement motivation.

In the paragraphs above, we have reviewed the role of esteem as a process towards achievement and self-actualisation. Self-esteem is actually the degree one values oneself. Self-esteem has a close relation with self-concept, which refers to one's view about oneself. As a brief summary of literature about self-concept (e.g. Rotenberg, 1995 & Castle, 1974), it seems that it contains three aspects of personal characteristics:

- self-image (i.e. what the person is)
- ideal self (i.e. what the person would like to be)
- self-esteem (i.e. what the person feels about the discrepancy between what he/she is and what he/she would like to be)

So, self-esteem is a part of one's self-concept. Many learning theories regard self-concept as a basic predictor of all behaviour; including cognitive, social and emotional aspects of learning. It is widely accepted as having a positive relationship with academic achievement (e.g. Patterson, 1973; Hamachek, 1971). It might be reasonable to expect the ownership of a skill or knowledge, such as those required for the use of computers, will make a positive contribution towards the learners' self-concept and self-esteem. When a learner thinks of himself/herself as a good learner, or has been expected to be a good learner by himself or significant others, it is likely that he/she will act positively towards learning.

Learning motive measures in this study

Biggs is interested in the nature of learning motives and how to learn. He sub-divided learning motives into three categories: surface, deep and achieving. They are the three learning motive measures used in this study. The classification originates from the work of Marton and Saljo (1976) on learning approaches. They found that learners who used a surface approach to learning tended to regard the learnt information as discrete facts. So, learners with high surface learning motivation are expected to have a strong intention to learn by memorising facts or to satisfy the minimal needs, such as the intention to study for career purposes. Their life goals are indeed survivalist in nature. The expected learning outcome to be associated with surface learning motivation is description or reproduction. For learners who use a deep approach to learning, learning is a meaningful experience. They like to find relationships between new information and learnt knowledge, and between learnt facts. Learners with high deep motivation to learn have an intrinsic interest in learning and are able to grasp the heart of the problem. The expected learning outcome to be associated with deep learning motivation is understandings.

In normal circumstances, learners make use of both surface and deep approaches to learning, although some individuals favour one approach to another. Depending on the learning context, learners adjust the extent of the two approaches to learning. For example, in a test which focuses on memorising factual information, a learner who prefers using a deep approach to learning might use a surface approach to learn. The self-regulatory adjustment between approaches to learning is a way of organising oneself cost-effectively to maximise learning achievement. It involves meta-cognitive processes. A learner who uses an achievement motivation to learn is someone who can make flexible adjustments between the two learning motives in order to achieve the highest grade or performance. The measurement scale in this section is adapted from Biggs' (1992) SPQ and LPQ instruments. With wide validation among learners in Australia, New Zealand and Asia, Biggs thought that the classification applied to learners at primary, secondary and higher education levels. Similar orientations have also been found among learners in Europe, although they were described as achieving, meaning, reproducing and non-academic orientations (Entwistle, 1988a).

The computer can be used to facilitate deep learning in the following way:

- its speed and automatic feature may free learners from routine low-level learning tasks, leaving them with more attention to higher-level learning tasks,
- its provisionality feature may allow learners to experiment, try their ideas out with little fear of making mistakes, and
- its speedy and powerful hyperlink feature may facilitate learners to link concepts during knowledge construction.

Computers can also be used to facilitate surface learning because the capacity of information they bring may enrich the learners with more factual information. The capacity of information that a CD-ROM or the internet holds is huge. Learners with surface learning motivation also use the computers as a tool for their learning. Having said that, the learning outcome is greatly affected by the learner's and the teacher's aim and the context of use. So, consideration has to be paid to achievement motivation, which helps regulate surface and deep learning motivation. In relation to learning theories suggested by McClelland (1961), Atkinson (1980) and Atkinson & Raynor (1974), achievement motivation is an essential element for achievement. For pupils with high achievement motivation, learning with the use of computers is an additional means of learning. So, on the basis of the reviewed issues, it might be reasonable for us to expect that:

- the relationships between surface learning motivation and learning outcomes will be negative in nature,
- the relationships between the other two types of learning motivation (i.e. deep learning motivation and achieving motivation) and learning outcomes will be positive in nature, and
- the relationships between the three types of learning motivation above and each of the three computer-specific variables (i.e. self-rated competence in using computers, appreciation of software interactivity and attitude towards using computers) will be positive in nature.

In Biggs' classification, there are three types of learning motivation. Here are the self-rating items measuring of "surface learning motivation" (LMS):

The only reason I can see for working hard in school is to get a good job when I leave school.

I only want to stay in school long enough to get a good job.
For me studying is a way to get a better job.
I don't care if I finish primary school as long as I can get a job.
I just want to learn what I need to get a good job in school, no more.

Here are items measuring of "deep learning motivation" (LMD):

I find that my schoolwork can give me a good feeling inside.
I become interested in many school subjects when I work at them.
I find that many subjects can become highly interesting once I get into them.
I find most of the schoolwork interesting.

Here are the measures of "achievement motivation" (LMA):

I really want to do better than anyone else in my schoolwork.
I will work for top marks whether or not I like the subject.
I would see myself as an ambitious person and want to get to the top.
I want to obtain high marks because I like to beat the others.

Self-concept measures in this study

Self-concept is one's view of oneself. With considerations of various models about its structure, Bracken formulated an instrument measuring self-concept with confirmatory factor analyses on the basis of a multidimensional and hierarchical structured model (Marsh & Hattie, 1996; Bracken, 1996; Bracken, 1992). The two self-concept scales used in this study contain the characteristics of both. That means, each of them is made up of a number of relatively independent constructs related to the perception about oneself. The self-concept scale at a basic level can also be sub-divided into sub-scales in the second level, and each sub-scale also has its potential to be sub-divided as sub-scales in the lower level. Its structure allows these concepts to be organised in their order of importance, from general concepts to specific concepts. The two self-concept scales used in this study are adapted from the instrument developed by Bracken (1992) and incorporated ideas from Byrne (1996) and Marsh and Shavelson (1985). Bracken's instrument is one of the standardised instruments widely used for measuring self-concept. It includes six dimensions of self-concept as below:

"

- social,
- academic,
- competence,
- affect,
- family, and
- physical.

(Source: Bracken, 1992)"

Only the first two dimensions are selected for the purpose of this study because they are widely accepted as having a positive correlation with learning performance and effectiveness. The discussion about the relationships between self-esteem and academic achievement above also give support for the existence of an academic self-concept. By incorporating ideas from Byrne (1996) and Marsh and Shavelson (1985), the academic self-concept scale is further divided into three sub-scales in this study, namely:

- self-concept of maths ability,
- self-concept of language ability, and
- self-concept of academic ability and school achievement.

For children in primary education, their self-concept of social ability is greatly affected by the people they interact with. The establishment and maintenance of positive self-esteem is associated with success in learning (Smith, 1996). In contrast, lack of social interaction will negatively affect their learning, achievement and social development. In relation to the use of computers, there is no clear evidence suggesting the presence and the nature of the relationships between computer usage and social ability or social self-concept. Some writers warned that social isolation was a potential pitfall of computer-based learning (e.g. Kreuger et. al., 1989; Moore, 1993) and suggested that primary teachers had to avoid having one child working alone at the computer (Crompton, 1989, Kreuger et. al., 1989).

In contrast, some writers thought that the communication capability of the computers nowadays could facilitate communication between learners in local classrooms, provided that sufficient ICT resources, teacher's time, attention and careful planning were given (e.g. Crook, C., 1994; Eraut, 1991). The literature review so far cannot draw conclusive generalisations about the relationships between the use of computers and the social development of child at primary education level. As an instructional tool, the computer often acts as a patient tutor. The permanently available and always helpful features of the computer can reduce the fear of failure in learning. Therefore, we cannot rule out potential links between the use of computers and social self-concept. In applying the learner's human relationship to human-computer interaction, it is likely that pupils who are in favour of social interactions or those with high social self-concept may prefer working with the computers, as a virtual "partner".

On the basis of the discussion about the potential links between self-concept and the use of computers above, it is likely that:

- the relationships between each of the self-concept measures (i.e. self-concept of maths ability, self-concept of language ability, self-concept of academic ability and school achievement and social self-concept) and each of the learning outcome measures will be positive in nature,
- the relationships between each of the three academic self-concept measures (i. e. self-concept of maths ability, self-concept of language ability, self-concept of academic ability and school achievement) and each of the computer specific variables will be positive in nature.

The measures of general academic self-concept are divided into three sets of measures. Here are the measures of academic self-concept in numeracy work (ACM).

I usually do well in number work.
I am good at mathematics.
My mental maths is as good as most people in my class.
I usually feel good about how fast I work on numbers.

Here are the measures of academic self-concept in literacy work (ACR).

I can read as well as most people in my class.
I can write better than many people in my class.
I usually feel good about my reading skill.
It is pretty easy for me to have spelling mistakes.
I really understand most of what I read.

Here are the measures of academic self-concept in learning and school work (ACS).

Classmates usually like my ideas.
I often think very quickly.
I am proud of my schoolwork .
I am doing quite well in my class.

The measures of social self-concept (SC) are listed as below.

I have a lot of friends.
People pick on me.
I am a lot of fun to be with.
People tell lies about me.
Most people like to talk with me.
Most of the time I feel ignored.
I am accepted by people who know me.
I let people bully me too much.
People tell me their secrets.
I spend a lot of time feeling lonely.

Measures of concentration in this study

In the paragraphs above, we have introduced the relationship between motivation and concentration. Learning motivation is a drive to put in effort or to persist on learning tasks. It differs from concentration, which is the extent of mental engagement on a learning task expressed in behavioural actions. Time on-task is a measure of concentration in learning. It is widely accepted as a factor affecting effectiveness of learning and teaching. In referring to the characteristics of young children, Wood (1998a) stated that they were more easily distracted than adults. Their mental engagement is affected by:

"

- their intellectual development e.g. concentration span;
- their ability to develop and self-regulate some strategies that can free themselves from distractions; and
- the authenticity of the learning tasks e.g. too difficult for the child to understand or to make sense of.

(adapted from Wood, 1998, p.283-285)"

It means that a pupil's concentration on a specific learning task is not only affected by the personal characteristics of the learner, but is also affected by contextual variables of the learning process. High concentration is often associated with better learning outcome, and vice versa. Therefore, it is possible to expect that:

- the relationships between concentration and each of the three computer-specific variables will be positive in nature, and
- the relationships between concentration and learning outcomes will be positive in nature.

Here are the measures of concentration (LCN) in this study:

I often miss things during class time because I'm thinking of other things.
I am distracted from my studies very easily.
I pay full attention when I do my schoolwork.
I often think of other things when the teacher is teaching.
I am better in concentrating on schoolwork than many of my classmates do.
I always listen carefully when the teacher talks to the class

Other general measures of personal characteristics

Time management

In business or industry, management means the ability and techniques of efficient organisation, planning, direction, and control of the operations of a business. In the business of "learning", learners' ability and techniques to plan, organise, direct and control their study time effectively is one of the factors affecting learning outcomes. When learners schedule their time for learning, they gain control of the pace, sequence and duration of their own learning. By doing so, learners also take responsibility for their own learning. Pupils who have good time management skills can reduce interruptions and distractions, set priorities according to the importance of the tasks, allocate and schedule their time,...etc. They will:

- have better control of their time,
- spend their time on the most important things,
- be more efficient in the things they do,

- not waste time, and
- get more done in the time they have.

It might be sensible to expect that pupils who are good at managing their time are likely to have better learning outcomes than pupils who do not plan about this. For example, a group of pupils is given four days to memorise some facts. To remember these facts, some of them may spend an hour every day for their study, while some of them may spend four hours for their study on the fourth day. In terms of efficiency and retention, the former method of study is more effective than the latter one.

Similarly, pupils who spend an hour every day on the computers would probably have better learning outcomes (e.g. computer skills, subject learning outcomes) than pupils who spend four hours on the computer in a single day. There is very little if any research on the relationship between pupils' time management skills and their appreciation of software interactivity, or their attitude towards using computers. If these things are linked, a high level of self-rated competence in using computers may further lead to a positive attitude towards using computers and a later development of appreciation of software interactivity. Therefore, it might be reasonable to expect that:

- the relationships between time management and learning outcomes will be positive in nature, and
- the relationships between time management and each of the three computer-specific variables will be positive in nature.

Here are the measures of time management (TM).

I only study when there is pressure from teachers, parents, or other adults.
I often feel that I have little control over how I spend my time in play and study.
I find it difficult to organise my study time effectively.
I often put off work and leave too much to do at the ending time.

Perception of teacher-pupil relations

Skelton and Playfoot (1995) stressed that good teacher-pupil relationships is a characteristic of effective teachers, as it motivates children, develops their confidence and self-esteem, and helps to establish class control and to model the values of education. From the perspective of learning, all of the aspects of success above are dependent on the pupil's perception of the relationship. For example, a pupil may interpret the teacher's careful checking of their work as a symbol of high expectations. The pupil may put effort to their work in order to meet the requirements of the teacher. The teacher's interest and care about the pupil's work and the help they offer are favourable factors affecting learning. So, the quality and the intensity of the teacher-pupil interaction are factors affecting teacher effectiveness.

The computer provides an alternative learning medium other than a traditional learning environment that highly depends on teacher-pupil interaction. There are various possible reasons for preferring working with the computers to working with the teacher. Pupils may tend to escape from the control of the teacher because a computer can provide them an enjoyable experience with multimedia presentations. It might be interesting to investigate the relationship. Alternatively, teacher-pupil interaction may be transferable to human-computer interaction during which the computer functions as a "virtual" partner. This supports the formulation and the use of a set of items measuring pupil perception of teacher-pupil relations in this investigative study. To move forward, on the basis of the literature review, it might be reasonable for us to expect that:

- the relationships between perception of teacher-pupil relations and learning outcomes will be positive, and
- the relationships between perception of teacher-pupil relations and each of the three computer-specific variables will be positive.

Here are the measures of pupils' perception of teacher-pupil relations (TP).

My class teacher: takes a personal interest in me. do his/her best to help me. talks with each pupil. takes a personal interest in each pupil. is friendly to students. helps each pupil who is having trouble with the work. consider pupils' feelings. carefully checks all my work.

Computer-related measures

Self-rated competence in using computers

In the era of technology, many people think that computer operation skills (also known as IT skills) are essential prerequisites for learners. However, good IT skills alone are not sufficient to equip a pupil for using the computer for learning purposes. Knowledge about information technology is also needed. For instance, learning supported by the computer may become impossible if nobody knows how or realises the need to switch the power supply on. Pupils need to integrate their knowledge and skills together to tackle challenges concerning the use of computers in the applied setting. This is the reason why both knowledge and skills about using computers are taken into consideration. The term "self-rated competence in using the computer" is used to stand for these concepts in this chapter. It is a part of computer literacy. Self-rated competence in using computers does not include making critical judgements about the selection of information to be processed. It refers to confidence, ability and experience in using computers.

Some learners are competent in using computers, but some learners are anxious and/or have a negative attitude towards the use of computers. The two types of learner are expected to be at the two extremes of the scale. Some authors describe them as "computer addicted" and "technophobic", respectively (e.g. Brosnan, 1998 & Shotton, 1989). Learners with high self-rated competence in using computers can have fast and accurate control and operation of computer-related technology. Brosnan (1998, page 91) suggests that the extent of competence is positively related to spatial ability and field independence. So, in this study, self-rated competence in using computers is expected to have a positive relationship with learning outcomes.

Here are the measures of self-rated competence in using computers (COM) reported by pupils.

I think the computer is easy to use.
I am very confident in using computer software in my class.
I have common sense about computer related equipment.
It is easy to find the right key on the keyboard.
I am familiar with using the mouse.
I am confident in using e-mail and internet.
I often meet technical problems when using the computer.
I am good at drawing things on the computer.
I am good at using the CD-ROM.
I have experience in using spreadsheets on computer.

Attitude towards using computers

The attitude measure in this study is made up of statements addressing pupils' mental position or feeling concerning the use of computers. The measure is different from the measure of self-rated competence in using computers, which focuses on pupils' ability, experience and confidence. On the other hand, there are alignments between the two measures. Pupils who have a positive attitude towards using computers tend to be those who are interested or have confidence in using them. Negative attitude or psychological fear towards using computers would hinder success and the development of competence in using computers. Therefore, it might be reasonable to expect that the relationships between attitude towards using computers and learning outcomes will be positive in nature. It is also expected that the relationship between attitude towards using computers and software interactivity will be positive in nature. The more interactive the computer software application is, the more positive the pupils' attitude towards using computers will be. The paragraphs below will give further information about software interactivity.

Here are the measures of pupils' attitude towards using computers (AUC).

I am quite happy when I work on the computer. When I work on the computer, I do better than usual. I enjoy using the computer. I like most of the computer software in class.

Appreciation of software interactivity

In referring to the use of computers, interaction is a two-way communication between the learner and the computer. A learner may have different degrees of interaction when working with different software applications. The interactivity of software application greatly depends on the attitude and experience of the software development team members, such as instructional designers, content area specialists, and computer programmers. If the activity is a computer-based question and answer exercise, the extent of interactivity might be restricted by the ways of providing feedback. Highly interactive software application may provide the reasons why each of the distractors is not an appropriate answer. The interactivity could be as high as recording and considering the learners' responses in the flow of the activities, such as changing the level of difficulty of the content or providing some clues or prompts when the learner fails to give an answer after a certain limit of time.

Interactivity can be quantitatively interpreted as the opportunity for the learner to give correct responses and obtain feedback from the computer, and it can also be qualitatively interpreted as the chance to take control of their own learning (Milheim, 1996). According to Milheim, the essential ingredients for an effective interaction can be summarised as the following:

- immediacy of response i.e. learners can retrieve information when needed without delay,
- non-sequential access to information i.e. the information retrieval is responsive according to the learners' requirements,
- adaptability i.e. where communication is based on audience needs or requests,
- bi-directional communication i.e. between the learner and the information presented by the computer, and
- grain size i.e. the length of time between user responses, including learners' interruption of computer actions.

(adapted from Milheim, 1996, page 226)

The outline above was used as a guide for the construction of items measuring software interactivity, which include issues about immediacy of response, extent of user control, communication between the computer and the user,...etc. Furthermore, Jonassen (1995) extended the idea towards a self-directed learning philosophy. He stated that "technology support knowledge construction better when they are need or task driven, when interactions are learner-initiated and learner-controlled, and when interactions with the technologies are conceptually and intellectually engaging". This implies that the effectiveness of using computers depends on the chance for the learners to take part in what happens and choose the topics according to their learning needs. This gives support to the need for including a measurement scale concerning learners' value placed on software interactivity. It seems sensible to expect that the relationships between pupils' appreciation of software interactivity and the other two computer-specific variables (i.e. self-rated competence in using computers, attitude towards using computers) will be positive in nature. It might also be intuitively sensible to speculate that the relationships between pupils' appreciation of software interactivity and learning outcomes will be positive in nature.

Here are the measures of appreciation of software interactivity:

36. It is important that computer software should:

give quick responses.

allow users to control the learning pace.

have pictures and graphics.

allow users to produce things on it.

be interactive.

give the users a lot of chances to produce responses.

allow users to control over the sequence of presented information.

make appropriate responses according to users' needs or requests.

give users a lot of chances to interrupt the presentation.

give users a lot of chances to take part in various stages of learning.

have sound presentation.

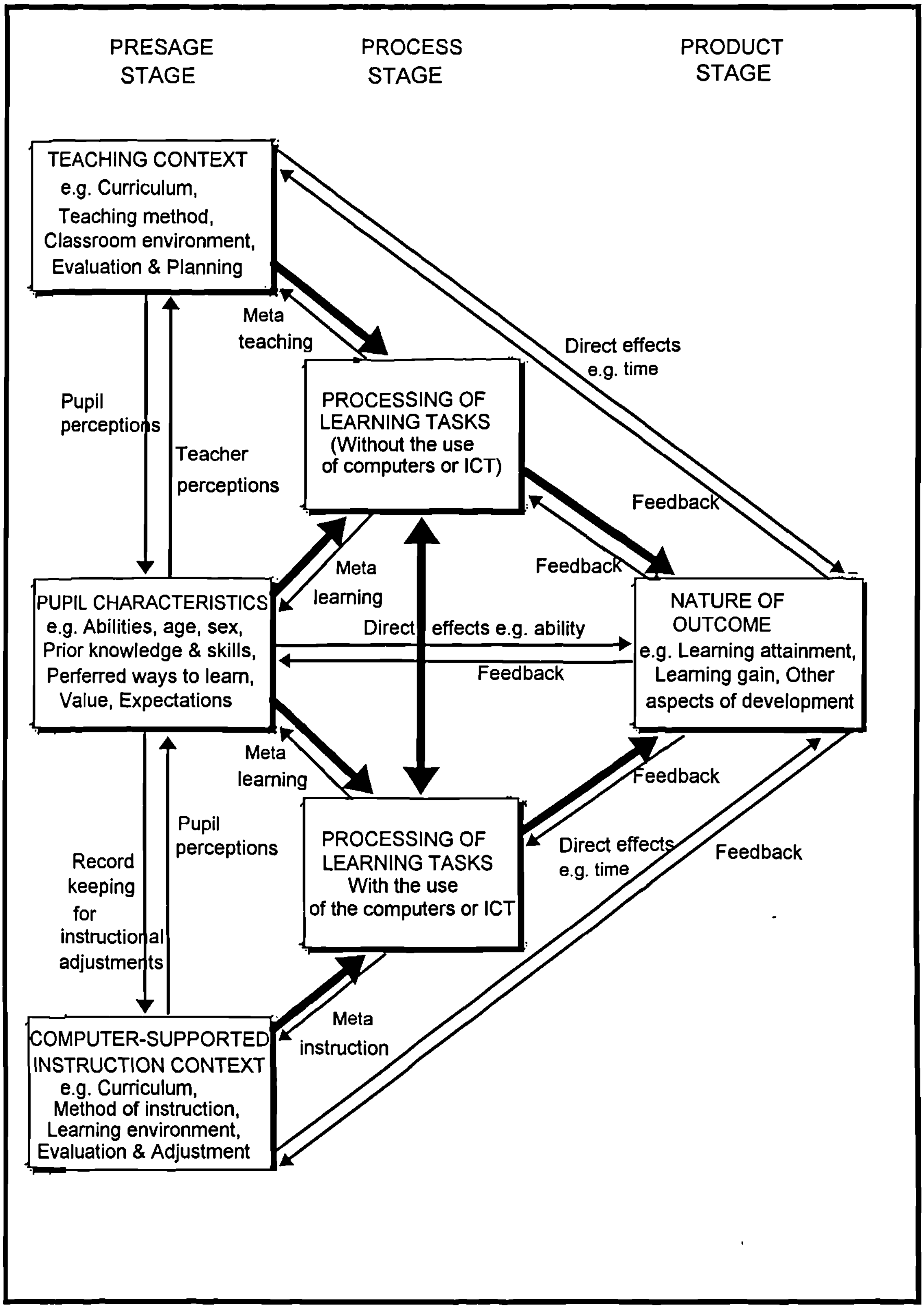
(3-1-3) The focus of investigation in relation to a proposed model of learning and teaching adapted from Biggs' 3P model

To explain the focus of investigation, it would be helpful to refer to the Illustration I3-1B. The model is derived from Biggs' 3P model (i.e. it is compatible with the "model of effective curricular learning and teaching supported by computers and other types of ICT" in Chapter 2), which has been widely accepted by many academics in the field of learning and instruction. The model has summarised learning and teaching processes into three major stages: Presage, Process and Product. The "presage" stage consists three educational-input components. Among them, "pupil factors" is the most important component. These factors include various aspects of personal characteristics, such as ability, age, sex, prior knowledge, skills, preferred ways to learn, value, expectations, ...etc. Other components of this stage consist of factors concerning the context of teaching and the context of computer-supported instruction.

As the focus of this chapter is on the interaction between the person and the computer, factors in these two components will not be addressed here. The major reason for this is to focus only on the effectiveness of pupils' learning, given that effective learning can occur in the absence of effective teaching (Harris, 1998). Results of school effectiveness research reported that about 80% of the total variance in pupil achievement were attributed to the differences between pupils (e.g. Saunders, 1998), and only 8% to 12% of the total variance were attributed to the differences between schools (e.g. Reynolds et. al., 1996, p.137). This supports the decision to carry out an investigation into person-computer interaction as a part of the learning processes. The teaching context factors will be addressed in the next chapter, in which various pedagogical issues will be taken into consideration. The discussion sections in this chapter will include the pedagogical implications concerning the use of computers and ICT derived from the reported findings.

There are two components in the "process" stage of the model. These include the processing of learning tasks with and without the use of computers or ICT. The two components of this stage affect each other. For example, a group of pupils working on the computers may share their ideas with another group of pupils working with paper and pencils. The learning motivation that a pupil gains from using a computer may be transferred to the processing of learning tasks without the use of a computer. The sharing of ideas and experience between a pupil in a non-computer group and a pupil in a computer group can be an effective learning activity. Nevertheless, each of the two components can operate independently on its own or simultaneously together. To depict the relationship, a thick bi-directional arrow is pointing at the two components of this stage in the model.

Illustration I3-1B: A model of learning and teaching processes (Adapted from: Biggs, 1992, Chapter 2, page 6)



There is only one component in the "product" stage, which includes learning outcomes such as measures of learning attainment in maths or/and reading, learning gains in maths or/and reading, pupils' attitude towards themselves and school learning, and other aspects of development. One component of the model may affect another component. A one-way arrow pointing from the "contributor" component to the "recipient" component of the model presents the casual relationship. In fact, most of the relationships between components of the model are reciprocal in nature. So, it is common to find a pair of one-way arrows pointing in opposite directions between two components of the model. For examples, pupil ability or concentration may have direct impact on learning outcome, while the feedback concerning their learning outcome could contribute to the formation or development of personal characteristics e.g. self-concept, motivation, attitude,...etc. Some of the arrows are thick, which mean that they are major learning and teaching activities in the model, and they make major contributions to learning outcomes.

The primary interest of this chapter is to investigate the links between pupil factors and learning outcomes, via the use of computers. The pupil factors are sub-divided into computer-specific factors and other learning-related factors. It is expected that if a significant relationship is found between a computer-specific factor and any learning outcome measure, it is most likely that computers or ICT are used in the processing of the learning tasks. In contrast, other learning-related factors may affect learning outcomes through various routes, with or without the use of computers or ICT in the processing of learning tasks. So far it is rather doubtful whether the aim of effective learning and teaching can be achieved by and only by maximising the effectiveness of learning and teaching through the use of computers. Computers or other types of ICT nowadays are not at all a replacement of normal learning and teaching in the primary classroom. Teaching and learning without the use of computers still plays a major role in classroom practice. Moreover, the processing of learning tasks with the use of computers is closely related to the processing of learning tasks without the use of computers. On this basis, the processing of learning tasks without the use of computers or ICT and the related links are also included as a focus of study in this chapter. Therefore, the components to be involved in this chapter are: pupil factors, processing of learning tasks with and without the use of computers or ICT, and learning outcomes.

There are links between pupil factors and learning outcomes, and there are links between these pupil factors. Links of the former type contain "direct" factors affecting learning outcomes and links of the latter type contain "indirect" factors (or learning process factors) which may have additional contribution to learning outcomes. With reference to the concept of value-added in Chapter 2, a fairer comparison of pupil performance can be made when the pupil ability factor is controlled. A significant finding of the relationship between a pupil factor and a learning outcome measure with control for ability is often a better indicator than a significant finding without control for ability.

To sum up, the focus of this study is on the relationship between personal characteristics and their interaction effects on learning outcomes. Special interest will be paid to computer-specific personal characteristics. The discussion of findings will focus on the implications for effective learning and effective pedagogy concerning the use of computers.

A reflection on the proposed methodology

Is it feasible to focus only on pupil characteristics and their effects on learning outcome, while teaching or instructional context factors are excluded from the investigations?

School effectiveness research show that about 80% of the variance of learning outcome is attributed to the differences between pupils. The percentage of explainable variance means that there is a need to investigate learning effectiveness from a pupil learning perspective. The investigation of the inter-relationships between learning outcomes, computer-specific personal characteristics and learning-related personal characteristics will be carried out by a series of correlation tests.

(3-1-4) Research method, data collection and data processing

Measuring instrument

Data about individual differences were collected from a survey form. It was carried out in mid December 1998. A total of 252 pupils from three schools participated in the study. The teacher administered the survey to all the pupils in class on that day.

Some items on the survey form were extracted or adapted from some standardised tests. For example, items were taken from the Learning Styles Inventory by Kolb (1985), the Learning Process Questionnaire and Study Process Questionnaire by

Biggs (1987a and 1992), the Learning and Study Strategies Inventory by Weinstein and Palmer (1990) and the Classroom Environment Questionnaire by Fraser (1986). Some items on the survey form were constructed by referring to the central ideas or adapting the content of specific items in other instruments. These included: Student Attitude Inventory by Entwistle et. al. (1971), Instructional Learning Environment Questionnaire by Knight and Waxman (1989), Multidimensional Motivation Instrument by Uguroglu et. al. (1981), Motivated Strategies for Learning Questionnaire by Pintrich et. al. (1991), Multidimensional Self Concept Scale by Bracken (1992), Learning Styles Inventory Form S-A by Cranfield (1980), Myers-Briggs Type Indicator (Briggs-Meyers & McCaulley, 1992 & Myers, 1962), and the instruments by Podmore and Craig (1989), Foliart and Lemlech (1989), Wise (1987), Kilgore (1995) and Parer, M.S. (1988). For the pre-set research focuses of this study, items selected from these instruments were mixed together with the adapted items and the newly constructed items to form as an item database. The order of appearance of these survey items is re-arranged according to research focuses of the study.

In the selection and adaptation of items from the original instruments, special attention was paid to the age of the respondents. First of all, the language used in the selected or adapted items seemed to be suitable for children at upper primary education levels. Secondly, attempts were made to reduce the length of the original questionnaire i.e. LSI-1985. Thirdly, the scale of measurement used in this study could be described as "fine" and "precise". Respondents were asked to indicate the extent of their agreement of a specific statement-item by putting a cross on a line. Response for each item was initially expressed in millimetres because all the respondent lines were 105 millimetres in length.

Illustration I3-1C: Line scale for responses in the survey

☹--☺

Each item of the survey form contains a statement and there is a line beneath each statement. At each end of the line, there is a picture representing "definitely not agree" or "definitely agree" about the statement. A copy of the scale is presented in Illustration I3-1C. In the survey, pupils were asked to put a cross somewhere on the line to indicate the extent of their agreement or disagreement about each of the statements. A copy of the questionnaire is attached in Appendix 3-A. It was expected that the design would alleviate some of the weaknesses of traditional response scales, such as a rank order scale or Likert scale. It appeared to the researcher that the use of a fine scale on a line was appropriate for pupils in primary education. Unlike the LSI-1985, the scales in this instrument are independent measures of the respective learning orientations.

The research design sought to link information about selected aspects of individual differences with pupils' educational outcomes. There were two major sources of data about the outcomes: Pupil level data from PIPS project and Reading Progress tests data from TTAICT project. We shall come back to this in the section about data collection below.

Measures of learning outcome

The outcome variables of this chapter were based on data collected from the PIPS project at University of Durham. Full descriptions about them can be found in Section 2-3-4 in Chapter 2.

A reflection on the instrument construction

There was a major weakness in the instrument construction. The survey form was too lengthy for pupils from 7 to 11 years old to complete. Some of the items were regarded as "duplicated items" by several pupils. In fact, they were similar items measuring different aspects of the same construct. Several teachers who administered the questionnaire found some children had difficulty in concentration when completing it. The weakness could have been avoided by dividing the sample population into blocks. Content of the survey could have been divided into several survey-questionnaires with a shorter length. With this arrangement, pupils in each block would be asked to complete only the specific survey items designed for them. Meanwhile, the present sampling method would collect data on all the variables of interest to the study from each pupil sample in the study. It allows a large sample size for investigating the relationships between the within-subject variables in the study. Therefore, the weakness in instrument construction has a trade-off in data analysis and generalisability of findings.

Sampling and data collection

It might be true that some aspects of individual differences may not exist among children of very young age. For instance, no one is certain if individual differences in learning styles exist among pre-school children. Even if individual differences do exist among a group of children, many aspects of the individual differences were technically difficult or time consuming to measure. Therefore, only children at the upper primary level were selected for this study. The survey was administered on a group basis.

The questionnaire was administered by the class teacher in March 1999. On the date when the survey was carried out, all the pupils in class were involved in the survey. Teachers read the questions and the options aloud for the pupils. The returned survey form provided information about 253 pupils from 3 schools. The first school is a large school. The school is outstanding in the provision of ICT equipment, and it consistently produces above average learning gains, as measured by PIPS value-added data. The pupils are from mixed socioeconomic backgrounds. The data were obtained from 168 pupils in Year 4 and in Year 5 of the school. The second school is a high-achieving suburban school. The pupils are mainly from advantaged backgrounds. The data were obtained from 61 pupils from a Year 4 class and a Year 6 class of the school. The last school is a small school with pupils from mixed socioeconomic background. The data is obtained from 24 pupils of a Year 6 class of the school. The class also produced above average learning gains in year 1998/99, as measured by PIPS value-added data. About 47% of the pupils were involved in the TTAICT project for ICT-related development in the academic year 1997/98 and 1998/99.

Data treatment and formulation of measurement scales

The collected data were then converted into composite variables using a 21-point scale. Each of the composite variables in this study was a scale of measurement formulated by a group of items in the survey form. The value of data ranged between -10 to 10. There were two major reasons for the decision. Firstly, it was technically easy and precise to convert the data into a 21-point scale. Secondly, the choice of 10 units on each side of the scale was thought to be a convenient way to indicate the extent of the agreement, leaving the value of "0" as neutral. Table T3-1-1, gives details about the formulation of the scale and the alpha statistics.

Most of the statements in the survey form were presented as a positive pole of the respective measurement scale, but some of them were presented as negative poles of the scale. To maintain consistency in measurement scale representation, statements of the latter type were reversed in polarity. For instance, the "37p" in column 3 of Table T3-1-1 is a representation of item number 37 on the survey form, which has been reversed in polarity. The "38" in column 3 of the table is a representation of item number 38. As it was a positive aspect of the scale, transformation was not needed. Each of these composite variables was constructed as a scale of measurement of a dimension of individual differences. It is formulated by averaging the value of several survey items designed for measuring the construct.

The internal consistency between items of the scale was assessed by alpha statistics. In relation to the type of data, a scale with an alpha statistic between .70 to .80 seemed to be reasonably reliable. It would mean that data of items of the scale were reasonably consistent. A scale with an alpha statistic around .65 seemed to be marginally reliable, but a scale with an alpha statistic below .60 would imply that it was not reliable enough. For example, the alpha statistics of the learning style sub-scales range from .43 to .58, based on data obtained from 252 pupils. That means the internal consistencies are below the average acceptable standard. The alpha statistics of the original LSI-1985 ranged from .73 to .83, based on the sample size of 268 adults. As the size of the samples did not seem to be the major cause for the low internal consistency, the age of the children could be a possible cause.

Table T3-1-1: A list of computer-specific variables and other learning-related variables that affect human-computer interaction for learning purposes

Var. Abbrev.	Name of the composite variable	Alpha (21-pt scale)	Variable formulation: The average of the following items/scales on the survey form
LSA	Learning styles subscale A: Concrete Experience	.5167	1a, 2a, 3a, 4a, 5a, 6a, 7a
LSB	Learning styles subscale B: Reflective Observation	.5471	1b, 2b, 3b, 4b, 5b, 6b, 7b
LSC	Learning styles subscale C: Abstract Conceptualization	.5893	1c, 2c, 3c, 4c, 6c, 7c
LSD	Learning styles subscale D: Active Experimentation	.4340	1d, 2d, 3d, 4d, 5d, 7d
LSCA	Relative position on prehensive dimension of learning (Abstract Conceptualization - Concrete Experience)		LSC - LSA
LSDB	Relative position on transformative dimension of learning (Active Experimentation - Reflective Observation)		LSD - LSB
COM	Competence in using computers (self-rated)	.6480	8, 10, 11, 12, 13, 14, 15p, 16, 18, 19
TP	Teacher-pupil relation (perception of)	.7861	20b, 20c, 20d, 20f, 20g, 20i, 20k, 20o

LMS	Learning motive subscale S: Surface learning motivation	.6404	21, 24, 27, 30, 33
LMD	Learning motive subscale D: Deep learning motivation	.5726	22, 25, 28, 31
LMA	Learning motive subscale A: Achievement motivation	.6523	23, 26, 29, 32
NT	Value on Software Interactivity	.7309	36a, 36b, 36c, 36d, 36e, 36f, 36g, 36h, 36i, 36j, 36k
LCN	Concentration in learning	.5925	37p, 38p, 39, 40p, 41, 43
AUC	Attitude towards using computers	.6041	44, 45, 47, 48
AC	Academic Self-concept (in general)	.7982	50, 51, 52, 53p, 54, 55p, 56, 57, 58, 59, 60p, 61, 62, 63, 64
ACM	Academic self-concept subscale M: Academic Self-concept in Numeracy work	.7927	50, 56, 59, 62
ACR	Academic self-concept subscale R: Academic Self-concept in literacy work	.5782	51, 54, 57, 60p, 63
ACS	Academic self-concept subscale S: Academic Self-concept in Learning and School work	.5756	52, 58, 61, 64
SC	Social Self-concept	.7773	65, 66p, 67, 68p, 69, 70p, 71, 72p, 73, 74p
TM	Time Management	.5261	75p, 78p, 79p, 80p

To facilitate statistical work with ANOVA technique, a set of grouping variables was formulated on the basis of the composite variables above. The idea was to classify pupils into two groups of roughly equal size. For example, according to the value of the data of the composite variables LSA, pupils were divided into two groups. Pupils who had low agreement with statements about concrete experience learning styles would have been labelled as "1" in the grouping variable, and pupils who had high agreement with statements about concrete experience learning styles would have been labelled as "2" in the grouping variable. Consideration was also given to the question about the learner's awareness and approval of the ownership of these personal characteristics. In contrast, a "disagreement" to a statement about an ownership of a personal characteristic cannot be directly interpreted as an ownership of an opposing personal characteristic. So, it would be more appropriate to interpret "disagreement" of the statements in the survey form as a "low" agreement of the ownership of a specific personal characteristic.

(3-1-5) The inter-relationships between computer-specific characteristics, other learning-related characteristics and learning effectiveness

The inter-relationships between computer-specific characteristics, other learning-related characteristics and learning effectiveness are investigated in two research studies. The first one focuses on the links between personal characteristics and learning outcomes, and the second one focus on the interaction between computer-specific characteristics and other learning-related characteristics.

(3-1-5-1) The links between pupil characteristics and learning effectiveness: Pedagogical implications in relation to the use of computers or ICT

This section is sub-divided into two parts. The first part is focused on the relationships between personal characteristics and learning outcomes. The second part is focused on the inter-relationships between personal characteristics, including computer-specific characteristics and other learning-related characteristics. Special attention is paid to the pedagogical implications concerning the use of computers or ICT.

Research design

The research design is correlational. A series of correlation tests are used to investigate the links between pupil characteristics and learning effectiveness. An alternative version of the correlation tests is computed with control for pupils' verbal and non-verbal abilities. It is hoped that the analyses will inform and generate pedagogical ideas.

Research hypotheses

Research hypotheses concerning personal characteristics and learning outcomes

In relation to the literature review above, it might be reasonable to assume that each of the following variables will have a positive relationship with each of the learning outcome measures mentioned in section 3-1-4 above and section 2-3-4 in Chapter 2. These include:

- competence in using computers (self-rated),
- attitude towards using computers,
- software interactivity (value on),
- concrete experience orientation of learning,
- reflective observation orientation of learning,
- abstract conceptualisation orientation of learning,
- active experimentation orientation of learning,
- teacher-pupil relations (perception of),
- deep learning motivation,
- achievement motivation,
- concentration (in learning),
- academic self-concept (in general),
- self-concept of maths ability,
- self-concept of language ability,
- self-concept in school and learning,
- social self-concept and
- time management.

Nevertheless, it is expected that the surface learning motivation will have a negative relationship with each of the learning outcome measures mentioned above.

Having said that, the focus of the investigation will be placed on the relationships between each of the three computer-specific variables and the learning outcome variables. The relationships between each of the learning-related variables and the learning outcome variables are not the major interest of this study. The issues will be addressed only if they relate to the use of computers. For instance, the interaction between the effects of computer-specific variables and the effects of learning-related variables on learning outcomes will be part of the investigation. Pedagogical implications concerning the use of computers will also be a supplementary part of the investigation.

Research hypotheses concerning learning-related variables and computer-specific variables

It is assumed that there are positive relationships between each of the computer-specific variables (namely, self-rated competence in using computers, attitude towards using computers and appreciation of software interactivity) and each of the following personal characteristics:

- concrete experience orientation of learning,
- reflective observation orientation of learning,
- abstract conceptualisation orientation of learning,
- active experimentation orientation of learning,
- teacher-pupil relations (perception of),
- surface learning motivation,
- deep learning motivation,
- achievement motivation,
- concentration (in learning),
- academic self-concept (in general),
- self-concept of maths ability,

- self-concept of language ability,
- self-concept in school and learning,
- social self-concept, and
- time management.

Null hypotheses

It is assumed that:

- there is no relationship between each of the personal characteristics variables and any learning outcome measures mentioned above.
- there is no relationship between each pair of personal characteristics variables mentioned above.

Results and discussion of data analyses

Results of descriptive statistics and t-tests

The means, standard error of the means, standard deviations and other descriptive statistics about the initial analyses are reported in Table T3-1-2. The analysis is based on data collected from 252 pupils. The mean statistics of the four learning orientations allows us to know about pupils' general preferences in perception and in processing. The results indicate that pupils in the study have a preference for an abstract conceptualisation orientation of perception to a concrete experience orientation. They also prefer an active experimentation orientation of processing as opposed to a reflective observation orientation. The findings were supported by the results of paired t-tests, which were found to be statistically significant at $p < .01$ level. With reference to the experiential learning theory, the implication of that would be pupils at upper primary education levels have a general preference for perceiving things by "thinking" than by "feeling", and a preference for processing things by "doing" than by "watching". Among the four orientations, pupils had the strongest preference for using active experimentation and had the weakest preference for using concrete experience.

The results of paired t-tests showed that the mean for deep learning motivation was higher than the mean for surface learning motivation. The mean for deep learning motivation was higher than the mean for achievement motivation. Both of these differences were statistically significant at $p < .01$ level. The mean for achievement motivation was significantly higher than the mean for surface learning motivation at $p < .05$ level. The findings imply that the pupils involved had a strong intrinsic interest in learning. They also had an interest in achieving well among their peers, but their motivation toward career prospects was rather weak.

The mean of academic self-concept in literacy work was found to be significantly lower than the mean of academic self-concept in numeracy work and the mean of self-concept in school and learning, respectively. Results of the two t-tests showed that the differences were significant at $p < .01$ level. This might reveal that pupils were less confident in literacy than in numeracy or in school learning. There was no significant difference between the mean of pupils' academic self-concept in numeracy work and that of in-school learning. The mean of pupils' general academic self-concept was also found to be higher than the mean of their social self-concept. The results of a t-test indicated that the difference was statistically significant at $p < .01$ level.

All the means of the composite variables are positive numbers, which seem to indicate that pupils in this study are generally aware of the presence of these aspects of individual differences. Alternatively, one may query if this was a result of the positive nature of most of the statements in the survey. It led to a further query about the reversibility of the negative statements, as a transformation procedure of the scales. For clarification, an investigation was made on the scales that were comprised of negative statements. The "time management" scale was a typical one. The mean of the scale was slightly positive, which implied that pupils in general were not aware that they had problems in time management. So, results of the investigation did not support the alternative explanation. It was unlikely that the positive nature of the means was due to the design of survey items.

Table T3-1-2: Pupil Level Descriptive Statistics

Variable Name (in brief)	Var. Abbrev.	Minimum	Maximum	Mean	Stand. Err.	S.D.
Concrete experience	LSA	-9	10	3.10	.21	3.37
Reflective observation	LSB	-7	10	4.48	.21	3.36
Abstract conceptualisation	LSC	-9	10	4.50	.24	3.74
Active experimentation	LSD	-4	10	6.33	.17	2.75
Competence in using computers	COM	-4	10	4.05	.21	3.32
Teacher-pupil relation	TP	-8	10	6.74	.23	3.66
Surface learning motivation	LMS	-10	10	3.37	.31	4.94
Deep learning motivation	LMD	-10	10	6.58	.24	3.76
Achievement motivation	LMA	-10	10	4.29	.32	5.01
Appreciation of software interactivity	NT	-6	10	6.70	.18	2.88
Concentration	LCN	-10	10	1.26	.27	4.27
Attitude towards using computers	AUC	-7	10	7.96	.19	3.08
Academic self-concept (general)	AC	-6	10	4.00	.22	3.52
Self-concept of maths ability	ACM	-10	10	4.63	.35	5.55
Self-concept of language ability	ACR	-10	10	3.52	.26	4.12
School and learning self-concept	ACS	-10	10	4.36	.28	4.39
Social self-concept	SC	-10	10	3.10	.28	4.49
Time management	TM	-10	10	.21	.33	5.28

Pedagogical implications in relation to the use of computers or ICT

In the process of learning, the results showed that pupils involved in this study appeared to be relatively "active" in doing things and relatively "intuitive" in thinking about things. In relation to learners with this style, they would receive the benefit of using computers as mindtools. The computer will function as an intellectual partner (or "virtual" partner) in cognitive learning tasks. With insights developed by pupils, it actively supports pupils in constructing their own knowledge structure. The author thinks that the workers in primary education should focus not only on the increase in the amount of knowledge content of pupils, but also on their development or construction of knowledge structure. Unfortunately, the latter aspect of work is often neglected. The understanding of the links between concepts will enable the learner to deduce or generate new knowledge. The development of knowledge structure is valuable for empowering the pupils with thinking skills for future learning and problem-solving exercises. Nevertheless, if the findings related to human-computer interaction were generally applicable to children at upper primary levels, it might be reasonable for us to draw two inferences on the basis of the reviewed literature about the use of computers:

1. Pupils at this age will appreciate the interactive learning activities supported by the computer and the use of multimedia presentations.
2. Pupils at this age will benefit a lot from simulated presentations of abstract concepts or processes provided by computers.

Findings about pupils' motivational preferences could be useful to enhance pupil learning. Teachers, educators, instructional designers and software designers have to pay special attention to develop and extend pupils' intrinsic interests. For example, a wide range of choice between different learning topics may be needed in order to suit the interests of different individuals. Encouragement in achieving well among their peers may be more effective than encouragement about better future career prospects. As the pupils involved were relatively less confident in literacy, it may be necessary to reduce the frequency of appearance of lengthy or redundant text in learning material or on the computer monitor screen. The weakness might be alleviated by providing additional support in literacy, such as remedial teaching, using electronic books or text-to-speech support facilities on the computer.

Results of correlation statistics

Results of the correlation between personal characteristics and learning outcomes are presented in Table T3-1-3. The significant results can be checked against the partial correlation results presented in Table T3-1-4, with control for pupils' verbal and non-verbal abilities. Correlation results reported in the latter table were computed with control for pupils' performance in the picture vocabulary test and in the problem of positions test. That means the significance of association has been tested when pupils' verbal and non-verbal abilities are taken into account. On this basis, the significant relationships found are more likely to be a result of learning, rather than a direct effect between pupil factors and the outcome measure.

Results of inter-correlation between these aspects of personal characteristics are presented in two tables. Table T3-1-5 contains information about the inter-item correlation statistics between the selected aspects of personal characteristics in this study. Table T3-1-6 contains the same correlation statistics, when pupils' verbal and non-verbal abilities are taken into account. In these tables, the level of two-tailed statistical significance are reported with an "*" to stand for $p < .05$ level or an "**" to stand for p < .01 level. Several features are identified from the results of analyses. They are listed as below:

Table T3-1-3: Results of correlation tests between pupil variables and outcome variables (in 1998/99)

	o_zma	o_zre	o_zaa	o_zpp	o_zpv	o_we	r_zoma	r_zore	r_zoaa	zat_ma	zat_re	zat_sh
LSA	.22* (112)	.08 (112)	.18 (114)	.07 (111)	-.06 (113)	.03 (110)	.27** (109)	.10 (109)	.23* (110)	.29** (112)	.05 (112)	.33** (112)
LSB	.09 (112)	.03 (112)	.06 (114)	.04 (111)	-.03 (113)	.01 (110)	.14 (109)	.05 (109)	.10 (110)	.08 (112)	-.04 (112)	-.13 (112)
LSC	.17 (112)	.16 (112)	.18 (114)	.19 (111)	-.03 (113)	.12 (110)	.13 (109)	.12 (109)	.15 (110)	.19* (112)	.01 (112)	.14 (112)
LSD	.12 (112)	.10 (112)	.12 (114)	-.01 (111)	.08 (113)	.08 (110)	.09 (109)	.08 (109)	.10 (110)	.04 (112)	.15 (112)	.16 (112)
LSCA	-.03 (112)	.08 (112)	.01 (114)	.11 (111)	.02 (113)	.09 (110)	-.10 (109)	.03 (109)	-.05 (110)	-.06 (112)	-.03 (112)	-.14 (112)
LSDB	-.01 (112)	.05 (112)	.03 (114)	-.05 (111)	.08 (113)	.05 (110)	-.07 (109)	.01 (109)	-.02 (110)	-.05 (112)	.14 (112)	-.01 (112)
COM	.33** (112)	.19* (112)	.28** (114)	.21* (111)	-.02 (113)	.13 (110)	.29** (109)	.17 (109)	.27** (110)	.29** (112)	.02 (112)	-.01 (112)
TP	-.12 (112)	-.14 (112)	-.14 (114)	-.20* (111)	-.15 (113)	-.21* (110)	.03 (109)	-.00 (109)	.02 (110)	.06 (112)	.04 (112)	.43** (112)
LMS	-.22* (112)	-.19* (112)	-.22* (114)	-.13 (111)	-.31** (113)	-.29** (110)	-.03 (109)	-.00 (109)	-.02 (110)	-.04 (112)	.06 (112)	.02 (112)
LMD	.01 (112)	-.01 (112)	.01 (114)	-.01 (111)	-.10 (113)	-.05 (110)	.05 (109)	.04 (109)	.06 (110)	.27** (112)	.06 (112)	.47** (112)
LMA	.02 (112)	-.02 (112)	.01 (114)	-.04 (111)	-.11 (113)	-.06 (110)	.12 (109)	.06 (109)	.11 (110)	.16 (112)	.07 (112)	.26** (112)
NT	-.07 (112)	-.09 (112)	-.07 (114)	-.01 (111)	- 03 (113)	-.00 (110)	-.04 (109)	-.08 (109)	-.06 (110)	.12 (112)	-.10 (112)	.04 (112)
LCN	.31** (112)	.25** (112)	.32** (114)	.03 (111)	-.06 (113)	.01 (110)	.37** (109)	.32** (109)	.42** (110)	.49** (112)	.09 (112)	.43** (112)
AUC	.06 (112)	.09 (112)	.08 (114)	.04 (111)	.12 (113)	.11 (110)	-.01 (109)	.05 (109)	.02 (110)	-.01 (112)	-.03 (112)	.13 (112)
AC	.38** (112)	.35** (112)	.40** (114)	.14 (111)	-.10 (113)	.05 (110)	.43** (109)	.44** (109)	.52** (110)	.42** (112)	.07 (112)	.25** (112)
ACM	.34** (112)	.16 (112)	.26** (114)	.08 (111)	-.15 (113)	.03 (110)	.43** (109)	.26** (109)	.42** (110)	.49** (112)	-.10 (112)	.28** (112)
ACR	.27** (112)	.37** (112)	.36** (114)	.10 (111)	-.04 (113)	.05 (110)	.27** (109)	.45** (109)	.43** (110)	.20* (112)	.22* (112)	.20* (112)
ACS	.13 (112)	.21* (112)	.21** (114)	.07 (111)	-.11 (113)	-.01 (110)	.20* (109)	.31** (109)	.31** (110)	.28** (112)	.05 (112)	.17 (112)
SC	.11 (112)	.16 (112)	.17 (114)	-.08 (111)	.01 (113)	-.04 (110)	.16 (109)	.22* (109)	.23* (110)	.06 (112)	-.04 (112)	.11 (112)
TM	.45** (112)	.42** (112)	.48** (114)	.19* (111)	.13 (113)	.23* (110)	.36** (109)	.36** (109)	.43** (110)	.09 (112)	.06 (112)	.13 (112)

Remark: Further detail about the outcome measures above is presented in section 2-1-3 in Chapter 2.

Keys: ***LSA*** refers to "concrete experience" learning orientation, ***LSB*** refers to "reflective observation" learning orientation, ***LSC*** refers to "abstract conceptualisation" learning orientation, ***LSD*** refers to "active experimentation" learning orientation, ***LSCA*** refers to "relative position on prehensive dimension of learning" (abstract conceptualization - concrete experience), ***LSDB*** refers to "relative position on transformative dimension of learning" (active experimentation - reflective observation), ***COM*** refers to "self-rated competence in using computers", ***TP*** refers to "teacher-pupil relation", ***LMS*** refers to "surface learning motivation", ***LMD*** refers to "deep learning motivation", ***LMA*** refers to "achievement motivation", ***NT*** refers to "appreciation of software interactivity", ***LCN*** refers to "concentration", ***AUC*** refers to "attitude towards using computers", ***AC*** refers to "academic self-concept (general)", ***ACM*** refers to "self-concept of maths ability", ***ACR*** refers to "self-concept of language ability", ***ACS*** refers to "school and learning self-concept", ***SC*** refers to "social self-concept", ***TM*** refers to "time management", ***o_zma*** refers to maths attainment, ***o_zre*** refers to reading attainment, ***o_zaa*** refers to academic attainement (the average of maths attainment and reading attainment), ***o_zpp*** refers to non-verbal ability measure (score in problems of position tests), ***o_zpv*** refers to verbal ability measure (score in picture vocabulary tests), ***o_we*** refers to context score, ***r_zoma*** refers to learning gains in maths, ***r_zore*** refers to learning gains in reading, ***r_zoaa*** refers to academic learning gains (the average of learning gains in maths and in reading), ***zat_ma*** attitude towards maths learning, ***zat_re*** attitude towards reading, ***zat_sh*** attitude towards themselves and school learning.

Table T3-1-4: Results of partial correlation tests between pupil variables and outcome variables (in 1998/99)

	o_zma	o_zre	o_zaa	r_zoma	r_zore	r_zoaa	zat_ma	zat_re	zat_sh
LSA	.25** (107)	.11 (107)	.24* (107)	.26** (105)	.11 (105)	.22* (106)	.28** (107)	.08 (107)	.34** (107)
LSB	.09 (107)	.04 (107)	.06 (107)	.13 (105)	.05 (105)	.10 (106)	.07 (107)	-.02 (107)	.13 (107)
LSC	.11 (107)	.16 (107)	.15 (107)	.10 (105)	.15 (105)	.15 (106)	.17 (107)	.05 (107)	.17 (107)
LSD	.11 (107)	.08 (107)	.12 (107)	.11 (105)	.06 (105)	.10 (106)	.04 (107)	.14 (107)	.15 (107)
LSCA	-.10 (107)	.06 (107)	-.05 (107)	-.11 (105)	.05 (105)	-.05 (106)	-.07 (107)	-.02 (107)	-.13 (107)
LSDB	-.00 (107)	.02 (107)	.03 (107)	-.05 (105)	-.01 (105)	-.02 (106)	-.04 (107)	.12 (107)	-.02 (107)
COM	.30** (107)	.18 (107)	.27** (107)	.27** (105)	.20* (105)	.28** (106)	.27** (107)	.0602 (107)	.02 (107)
TP	.02 (107)	-.03 (107)	.01 (107)	.03 (105)	-.02 (105)	.01 (106)	.07 (107)	.04 (107)	.44** (107)
LMS	-.10 (107)	-.02 (107)	-.06 (107)	-.08 (105)	.01 (105)	-.04 (106)	-.05 (107)	.10 (107)	.03 (107)
LMD	.05 (107)	.05 (107)	.07 (107)	.04 (105)	.05 (105)	.06 (106)	.27** (107)	.07 (107)	.48** (107)
LMA	.08 (107)	.06 (107)	.09 (107)	.11 (105)	.07 (105)	.11 (106)	.16 (107)	.09 (107)	.27** (107)
NT	-.07 (107)	-.09 (107)	-.07 (107)	-.04 (105)	-.08 (105)	-.06 (106)	.12 (107)	-.09 (107)	.04 (107)
LCN	.39** (107)	.35** (107)	.44** (107)	.36** (105)	.34** (105)	.42** (106)	.48** (107)	.11 (107)	.44** (107)
AUC	.01 (107)	.03 (107)	.02 (107)	.01 (105)	.04 (105)	.02 (106)	-.00 (107)	-.05 (107)	.12 (107)
AC	.43** (107)	.46** (107)	.52** (107)	.41** (105)	.48** (105)	.53** (106)	.41** (107)	.11 (107)	.28** (107)
ACM	.43** (107)	.27** (107)	.39** (107)	.42** (105)	.30** (105)	.42** (106)	.49** (107)	-.07 (107)	.31** (107)
ACR	.29** (107)	.46** (107)	.45** (107)	.25** (105)	.48** (105)	.43** (106)	.18 (107)	.25** (107)	.21* (107)
ACS	.16 (107)	.31** (107)	.30** (107)	.17 (105)	.34** (105)	.30** (106)	.26** (107)	.08 (107)	.18 (107)
SC	.17 (107)	.22* (107)	.26** (107)	.17 (105)	.21* (105)	.23* (106)	.07 (107)	-.05 (107)	.10 (107)
TM	.42** (107)	.40** (107)	.48** (107)	.37** (105)	.39** (105)	.45** (106)	.07 (107)	.07 (107)	.14 (107)

Remark: Further detail about the outcome measures above is presented in section 2-1-3 in Chapter 2. The partial correlation tests are performed with control for pupils' verbal and non-verbal ability measures.

Keys: ***LSA*** refers to "concrete experience" learning orientation, ***LSB*** refers to "reflective observation" learning orientation, ***LSC*** refers to "abstract conceptualisation" learning orientation, ***LSD*** refers to "active experimentation" learning orientation, ***LSCA*** refers to "relative position on prehensive dimension of learning" (abstract conceptualization - concrete experience), ***LSDB*** refers to "relative position on transformative dimension of learning" (active experimentation - reflective observation), ***COM*** refers to "self-rated competence in using computers", ***TP*** refers to "teacher-pupil relation", ***LMS*** refers to "surface learning motivation", ***LMD*** refers to "deep learning motivation", ***LMA*** refers to "achievement motivation", ***NT*** refers to "appreciation of software interactivity", ***LCN*** refers to "concentration", ***AUC*** refers to "attitude towards using computers", ***AC*** refers to "academic self-concept (general)", ***ACM*** refers to "self-concept of maths ability", ***ACR*** refers to "self-concept of language ability", ***ACS*** refers to "school and learning self-concept", ***SC*** refers to "social self-concept", ***TM*** refers to "time management", ***o_zma*** refers to maths attainment, ***o_zre*** refers to reading attainment, ***o_zaa*** refers to academic attainement (the average of maths attainment and reading attainment), ***o_zpp*** refers to non-verbal ability measure (score in problems of position tests), ***o_zpv*** refers to verbal ability measure (score in picture vocabulary tests), ***o_we*** refers to context score, ***r_zoma*** refers to learning gains in maths, ***r_zore*** refers to learning gains in reading, ***r_zoaa*** refers to academic learning gains (the average of learning gains in maths and in reading), ***zat_ma*** attitude towards maths learning, ***zat_re*** attitude towards reading, ***zat_sh*** attitude towards themselves and school learning.

- Among the three computer-specific variables reported in Table T3-1-3, the variable "self-rated competence in using computers" was found to be positively associated with learning outcomes, including maths attainment, reading attainment, academic attainment, non-verbal ability, learning gains in maths, academic learning gains and attitude towards maths. There was no direct relationship between "attitude towards using computers" and any of the learning outcomes. A possible explanation for this is that the "self-rated competence in using computers" variable is relatively closer to pupils' behaviour than the other two computer-specific variables.
- The correlation results were further examined by comparing them with the respective correlation results in Table T3-1-4. All the significant relationships were confirmed indicating that the pattern of relationships was still valid when pupils' verbal and non-verbal abilities were taken into account. The relationship between self-rated competence in using computers and reading attainment was the only exception. The positive relationship was found to be significant in Table T3-1-3, but not significant in Table T3-1-4. This leads to the question whether pupils' (self-rated) competence in using computers was associated with pupils' ability. The question was addressed by a significant ($p < .05$) correlation between self-rated competence in using computers and pupils' performance in problem of positions tests, which is an indication of pupils' non-verbal ability. The positive relationship between self-rated competence in using computers and spatial ability also gave support to the conclusion drawn in the literature review. In ordinary traditional primary classroom environments where computers or ICT are not used for learning and teaching, the mode of information processing is mainly verbal. In a computer supported learning environment, the mode of information processing

tends to be multi-sensory. Therefore, pupils with high self-rated competence in using computers could be better at processing visual and spatial information than pupils with low competence. None of the correlation statistics between appreciation of software interactivity and learning outcome measures was found to be statistically significant. The size of associations is close to zero.

Table T3-1-5: Results of inter-item correlation tests between pupil variables

	lsa	lsb	lsc	lsd	lsca	lsdb	com	tp	lms	lmd
lsa	1.00									
lsb	.45**	1.00								
lsc	.39**	.44**	1.00							
lsd	.22**	.26**	.27**	1.00						
lsca	-.49**	.03	.62**	.06	1.00					
lsdb	-.24**	-.71**	-.20**	.50**	.02	1.00				
com	.20**	.19**	.21**	.24**	.03	.01	1.00			
tp	.20**	.22**	.23**	.11	.04	-.12	-.02	1.00		
lms	.08	.11	-.08	.06	-.15*	-.05	.10	.03	1.00	
lmd	.35**	.34**	.32**	.19**	.00	-.16**	.17**	.46**	.21**	1.00
lma	.27**	.24**	.08	.11	-.16*	-.13*	.25**	.08	.34**	.30**
nt	.28**	.20**	.08	.27**	-.16*	.02	.20**	.01	.16*	.20**
lcn	.30**	.38**	.41**	.19**	.13*	-.19**	.27**	.21**	-.03	.31**
auc	.21**	.25**	.15*	.10	-.04	-.15*	.23**	.15*	.18**	.32**
ac	.19**	.13*	.28**	.18**	.11	.020	.38**	.02	-.04	.23**
acm	.11	.08	.21**	.09	.11	-.01	.35**	.03	-.05	.14*
acr	.20**	.13*	.21**	.17**	.03	.01	.29**	-.07	-.02	.19**
acs	.19**	.15*	.33**	.20**	.15*	.01	.22**	.17**	.08	.35**
sc	-.01	.06	.06	.05	.07	-.02	.00	.04	-.01	.08
tm	.09	.07	.12	.08	.04	-.01	.00	-.11	-.30**	-.06

	lma	nt	lcn	auc	ac	acm	acr	acs	sc	tm
lsa										
lsb										
lsc										
lsd										
lsca										
lsdb										
com										
tp										
lms										
lmd										
lma	1.00									
nt	.19**	1.00								
lcn	.24**	.10	1.00							
auc	.18**	.19**	.16*	1.00						
ac	.17**	.08	.38**	.18**	1.00					
acm	.10	.07	.26**	.15*	.79**	1.00				
acr	.11	.06	.27**	.17*	.77**	.39**	1.00			
acs	.27**	.08	.36**	.15*	.73**	.43**	.50**	1.00		
sc	-.03	-.00	.19**	.07	.36**	.22**	.28**	.37**	1.00	
tm	-.09	-.03	.24**	-.10	.25**	.15*	.26**	.08	- .24**	1.00

Keys: ***LSA*** refers to "concrete experience" learning orientation, ***LSB*** refers to "reflective observation" learning orientation, ***LSC*** refers to "abstract conceptualisation" learning orientation, ***LSD*** refers to "active experimentation" learning orientation, ***LSCA*** refers to "relative position on prehensive dimension of learning" (abstract conceptualization - concrete experience), ***LSDB*** refers to "relative position on transformative dimension of learning" (active experimentation - reflective observation), ***COM*** refers to "self-rated competence in using computers", ***TP*** refers to "teacher-pupil relation", ***LMS*** refers to "surface learning motivation", ***LMD*** refers to "deep learning motivation", ***LMA*** refers to "achievement motivation", ***NT*** refers to "appreciation of software interactivity", ***LCN*** refers to "concentration", ***AUC*** refers to "attitude towards using computers", ***AC*** refers to "academic self-concept (general)", ***ACM*** refers to "self-concept of maths ability", ***ACR*** refers to "self-concept of language ability", ***ACS*** refers to "school and learning self-concept", ***SC*** refers to "social self-concept", ***TM*** refers to "time management".

Table T3-1-6: Results of inter-item correlation (partial correlation) tests between pupil variables

	LSA	LSB	LSC	LSD	LSCA	LSDB	COM	TP	LMS	LMD
lsa	1.00									
lsb	.45**	1.00								
lsc	.38**	.44**	1.00							
lsd	.23*	.27**	.28**	1.00						
lsca	-.50**	.03	.61**	.07	1.00					
lsdb	-.23*	-.70**	-.19**	.49**	.02	1.00				
com	.18	.18	.17	.26**	.00	.03	1.00			
tp	.21*	.23*	.27**	.11	.07	-.12	.01	1.00		
lms	.07	.11	-.09	.09	-.14	-.03	.10	-.03	1.00	
lmd	.35**	.33**	.32**	.20*	.00	-.16	.17	.46**	.19*	1.00
lma	.26**	.23*	.08	.11	-.15	-.13	.25**	.07	.32**	.29**
nt	.28**	.20*	.08	.27**	-.16	.02	.21*	.01	.16	.19*
lcn	.29**	.37**	.40**	.20*	.13	-.19	.26**	.21	-.05	.30**
auc	.22*	.26**	.16	.09	-.04	-.16	.24*	.18	.23**	.34**
ac	.17	.11	.25**	.20*	.09	.04	.35**	.03	-.07	.22*
acm	.10	.07	.19**	.10	.10	.02	.33**	.03	-.09	.12
acr	.19	.12	.19**	.18	.02	.03	.27**	-.05	-.03	.19
acs	.17	.15	.31**	.21*	.14	.03	.20*	.18	.05	.35**
sc	.00	.07	.08	.05	.08	-.02	.02	.02	-.01	.08
tm	.08	.07	.09	.07	.02	-.01	-.03	-.07	-.27**	-.05

	LMA	NT	LCN	AUC	AC	ACM	ACR	ACS	SC	TM
lsa										
lsb										
lsc										
lsd										
lsca										
lsdb										
com										
tp										
lms										
lmd										
lma	1.00									
nt	.19	1.00								
lcn	.23*	.10	1.00							
auc	.19*	.20	.16	1.00						
ac	.17	.08	.37**	.19*	1.00					
acm	.08	.06	.25**	.17	.78**	1.00				
acr	.11	.06	.27**	.17	.77**	.38**	1.00			
ac_s	.27	.08	.35**	.16	.73**	.41**	.49**	1.00		
sc	-.03	-.00	.19*	.07	.39**	.23*	.29**	.39**	1.00	
tm	-.08	-.02	.25**	-.12	.24**	.15	.25**	.08	.26**	1.00

Remark: The partial correlation tests are performed with control for pupils' verbal and non-verbal ability measures.

Keys: ***LSA*** refers to "concrete experience" learning orientation, ***LSB*** refers to "reflective observation" learning orientation, ***LSC*** refers to "abstract conceptualisation" learning orientation, ***LSD*** refers to "active experimentation" learning orientation, ***LSCA*** refers to "relative position on prehensive dimension of learning" (abstract conceptualization - concrete experience), ***LSDB*** refers to "relative position on transformative dimension of learning" (active experimentation - reflective observation), ***COM*** refers to "self-rated competence in using computers", ***TP*** refers to "teacher-pupil relation", ***LMS*** refers to "surface learning motivation", ***LMD*** refers to "deep learning motivation", ***LMA*** refers to "achievement motivation", ***NT*** refers to "appreciation of software interactivity", ***LCN*** refers to "concentration", ***AUC*** refers to "attitude towards using computers", ***AC*** refers to "academic self-concept (general)", ***ACM*** refers to "self-concept of maths ability", ***ACR*** refers to "self-concept of language ability", ***ACS*** refers to "school and learning self-concept", ***SC*** refers to "social self-concept", ***TM*** refers to "time management".

- Table T3-1-4 shows that concrete experience learning orientation was found to be positively associated with learning outcomes. These include maths attainment, learning gains in maths, academic learning gains, attitude towards maths and attitude towards himself/herself and school learning. The size of the associations were .22 and .33, at $p < .05$ level. This learning orientation was positively related to appreciation of software interactivity and attitude towards using computers, respectively. In referring to Table T3-1-6, the size of the association was reported as .28 and .22, at $p < .01$ level. It implies that pupils who highly depend on this learning orientation will favour the use of computers, and they tend to value interaction with the computer. Association between this learning orientation and self-rated competence in using computers was not statistically significant, at $p < .05$ level.
- Active experimentation learning orientation was positively related to self-rated competence in using computers and appreciation of software interactivity, respectively. In Table T3-1-4, the size of the associations was .26 and .27, at $p < .05$. The hypotheses concerning the positive nature of the relationships were supported. Association between this learning orientation and attitude towards using computers was not statistically significant, at $p < .05$ level. Table T3-1-6 reported tests of the association between these personal characteristics. Active experimentation learning orientation was not found to be associated with any learning outcomes.
- The four orientations of learning style are positively correlated to each other. This is quite different from the negative nature of the inter-item correlation statistics reported in the manual of the LSI-1985 instrument (Kolb, 1985, page 6). This can be explained by the adaptation of the instrument specifically for this study. The

relationships between these items were freed from the influence of the negative inter-item relationships of the original instrument because a line scaling method was used to replace the original rank order scaling method. A further investigation was made into the pattern of inter-item correlation of the data collected from 74 teachers with the original rank order scaling method. Negative inter-item relationships were also found. Therefore, the revision of scaling method used in this study seemed to be a reasonable explanation for the positive inter-item relationships.

- In Table T3-1-6, reflective observation learning orientation was positively related to appreciation of software interactivity and attitude towards using computers, respectively. The size of the associations was .20 and .26, at $p < .05$ level. No significant association between reflective observation and self-rated competence in using computers was found. There was also no significant relationship between abstract conceptualisation and any of the three computer-specific variables, respectively.
- In Table T3-1-3, surface learning motivation was negatively related to maths attainment, reading attainment and academic attainment, at $p < .05$ level. That means, the hypothesis about the negative nature of the relationships was supported. There was also a significant negative relationship between surface learning motivation and picture vocabulary test scores, at $p < .05$ level. In Table T3-1-4, however, none of the three relationships were found. In Table T3-1-5, surface learning motivation was positively related to appreciation of software interactivity when the scores on problem of positions test and picture vocabulary test were not taken into account. The significance of the positive relationship no longer remained when statistical tests controlled for verbal and non-verbal ability

measures, as reported in Table T3-1-6. The positive relationship between surface learning motivation and attitude towards using computers was significant at $p < .05$ level, no matter whether verbal and non-verbal ability factors were taken into account. That means, the higher the motivation to learn aiming for memorising facts or for reproduction purposes, the higher appreciation of software interactivity and the attitude towards computers, respectively. No significant relationship between surface learning motivation and self-rated competence in using computers was found, at $p <.05$ level. So, the relationship is more likely to be psychological or attitudinal, rather than behavioural in nature.

- It might be worthwhile to note that no significant relationship was found between surface learning motivation and any of the learning outcome measures concerning pupils' attitude, at $p < .05$ level. On the contrary, deep learning motivation was positively related to attitude towards maths and attitude towards school and learning, respectively. The associations were .27 and .48 respectively, as reported in Table T3-1-4. Achievement motivation was also positively related to attitude towards school and learning, with an association size of .27 at $p < .05$ level. Both deep learning motivation and achievement motivation were positively related to each of the three computer-specific variables (i.e. self-rated competence in using computers, appreciation of software interactivity and attitude towards using computers), respectively. However, the significance of the associations was affected by verbal and non-verbal abilities. When pupils' problem of positions test scores and picture vocabulary were taken into account, the relationship between deep learning motivation and self-rated competence in using computers, and the relationship between achieving learning motivation and appreciation of software interactivity became insignificant. The results did not provide evidence to demonstrate the presence of indirect effects of computer-specific variables on attitudinal learning outcomes, but they indicate the potential of the computers in affecting attitude towards maths and attitude towards school and learning.

- The general academic self-concept scale and the three sub-scales were positively related to various types of learning outcome. Details of the significant relationships can be found in Table T3-1-3 and Table T3-1-4. The associations between each of these scales and each of the computer-specific variables were examined and reported in Table T3-1-5 and Table T3-1-6. Instead of describing each of the significant relationships, it would be interesting and useful for us to look at the general pattern of the relationships that were found to be statistically significant. To be brief, academic self-concept (general) has positive relationships with maths attainment, reading attainment, academic attainment, learning gains in maths, learning gains in reading, academic learning gains, attitude towards maths and attitude towards school and learning. It also has positive relationships with self-rated competence in using computers and attitude towards using computers at $p < .01$ level, respectively. The latter relationship was not found to be statistically significant at $p < .01$ level, when verbal and non-verbal abilities were taken into account. No significant relationships were found between each academic self-concept (sub-)scales and appreciation of software interactivity. The general pattern of the results gave support to the view that the ownership of skills and knowledge about using computers could make positive contributions to academic self-concept. When verbal and non-verbal abilities were also taken into account, positive attitude towards using computers was not strong enough to make significant contributions to academic self-concept.

- The results showed that there was a positive relationship between the perception of teacher-pupil relationship and attitude towards school and learning, at $p < .01$ level. A positive relationship between the perception of teacher-pupil relationship and attitude towards using computers, at $p < .01$ level was found in Table T3-1-5. However, no significant relationship was found between perception of teacher-pupil relationship and any of the computer-specific variables, when verbal and non-verbal abilities were taken into account.
- There were positive relationships between the concentration (in learning) and learning outcomes, including maths attainment, reading attainment, academic attainment, learning gains in maths, learning gains in reading, academic learning gains attitude towards maths and attitude towards school and learning. As reported in Table T3-1-3, the size of the association ranged from .25 to .49, at $p < .01$ level. Table T3-1-6 also showed the presence of a positive relationship between the concentration (in learning) and self-rated competence in using computers, at $p < .01$. No significant relationship was found between concentration (in learning) and any of the other two computer-specific variables (i.e. appreciation of software interactivity and attitude towards using computers), when verbal and non-verbal abilities were taken into account. This implies pupils who have good IT skills have higher concentration in learning with the use of computers, and vice versa.
- Self-concept was positively related to learning gains in reading and academic learning gains, respectively at $p < .05$ level. There was no significant relationship between social self-concept and any of the computer-specific variables, but it was positively related to concentration in learning. The expected relationships between social self-concept and computer-specific variables were not supported.

- Time management was positively related to maths attainment, reading attainment, academic attainment, learning gains in maths, learning gains in reading and academic learning gains. The significance of these associations remained when verbal and non-verbal abilities were taken into account. However, it was not related to any of the computer-specific variables. Therefore, the expected relationships were not supported.

Pedagogical implications in relation to the use of computers or ICT and suggestions for further research

- Although the relationships between self-rated competence in using computers and learning outcomes were found to be positive in nature, this does not mean that teachers can positively contribute to pupils' learning outcome by improving their self-rated competence in using computers. Among those with high self-rated competence in using computers, their self-rated competence in using computers is a necessary, but insufficient condition, for achievement and improvement in learning supported by computers. For those without competence in using computers, this is indeed a barrier for success in learning supported by computers. Therefore, for all pedagogical and instructional arrangements supported by the use of computers, teachers and educators need to consider pupils' competence in using the computers.
- Teachers have to avoid pupils' over-reliance on software interactivity, but their self-initiated interaction with the computers needs to be encouraged. Pedagogical attention has to be paid to the transfer of benefits from interaction with the

computer (e.g. learning motivation or concentration) to normal learning environments when computers are not used.

- The results showed the value for these pupils of learning by practical experience, such as sensations and feelings. Unfortunately, the descriptive statistics above showed that the usage of concrete experience learning orientation was the least common one among the four learning orientations. Theoretically speaking, a deficit in one of the four learning orientations will hinder the completion of a learning cycle. Similar to the need of "scaffolds" for the development of knowledge structure, pupils need practical experience to strengthen their conceptualised knowledge. Multimedia features of the computer could give support to this learning orientation by providing multi-sensory information through demonstrations and presentations. However, the extent of help is still greatly limited by technology. Considering the technology available nowadays and offering sensory information as a physiological experience (e.g. heat, softness, dryness...etc.) with the computers or ICT is very rare in everyday classrooms.
- As most of the relationships between computer-specific variables and learning motivation were found to be statistically significant, the results lend support to the hypothesis that the use of computers make a contribution to pupil motivation. Having said that, attention needs to be paid to the nature of the relationships. The links between computers and deep / achieving learning motivation were positive in nature, and the two types of motivation were also positively linked to pupils' attitude towards maths and school learning. The links between surface learning motivation and cognitive/attitude measures seemed to be negative in nature, although they were not statistically significant. So, teachers, educators and software designers have to pay attention to the instructional design and usage of

computers. Using computers to promote understanding should be encouraged, rather than just using them to facilitate factual recall or reproductive learning.

- Surface learning motivation, concentration (in learning) and academic self-concept (general) were positively related to various types of learning outcome, respectively. It is possible that self-rated competence in using computers may interact with these effects. Pedagogical and instructional decisions need to consider the nature of the interaction effects. The studies reported in section 3-1-5-2, are extended investigations with particular interest in interaction effects.
- To facilitate future research or making pedagogical decisions, it might be useful to sum up the potential aspects of learning outcomes that the use of computers may bring. The above results implied the possibility of the presence of an indirect positive relationship between attitude towards using computers and attitude towards school and learning, while perception of teacher-pupil relationship may act as intermediate variable. Self-rated competence in using computers also might have indirect positive effects on maths attainment, reading attainment, academic attainment, learning gains in maths, learning gains in reading, academic learning gains attitude towards maths and attitude towards school and learning, while concentration in learning may act as an intermediate variable. It is also possible that there are indirect positive relationships between each of the computer-specific variables (i.e. self-rated competence in using computers, appreciation of software interactivity and attitude towards using computers) and attitude towards school and learning, while deep learning motivation and achievement motivation may act as an intermediate variables, respectively.

(3-1-5-2) The interactions between computer-specific characteristics and learning-related characteristics

The aim of this section is to investigate the significance of interaction between computer-specific characteristics and other learning-related characteristics.

Research design

The major research design is two-way analysis of variance (ANOVA). Each independent variable in the study consists of two contrasting groups of pupils with roughly equal size. For instance, according to pupils' self-rated competence in using computers, about half of the pupils were classified as high competence computer users and about half of them were classified as low competence computer users. Similarly, according to pupils' responses to statements concerning academic self-concept (general), half of them were formed as a group of learners with high academic self-concept and another half of them formed as a group of learners with low academic self-concept. The section "data treatment and formulation of measurement scales" above has provided more information about classifying pupils into groups.

This study is sub-divided into three parts. In each part of the study, there was a series of seven 2-way ANOVA models. They were similar, although each of them had a different dependent variable. The major criterion for selection of independent variables was based on the results reported in Section 3-1-5-1. Each of them was significantly related to some measures of pupils' learning outcomes. Similarly, the seven dependent variables were selected because they were significantly related to the computer-specific variable "self-rated competence in using computers", as mentioned in Section 3-1-5-1. These dependent variables were: maths attainment, reading attainment, academic attainment, attainment in problem of positions test, maths learning gains, academic learning gains and attitude towards maths. The major research interest is on the interaction effects between the two independent variables.

Research hypotheses

On the basis of the discussions above, three mixed ANOVA designs were formulated to investigate the interaction effects. The research hypotheses made are listed below.

Part 1: The effect of interaction between self-rated competence in using computers and surface learning motivation on learning outcomes

It is expected that:

- each type of learning outcome is affected by self-rated competence in using computers;
- each type of learning outcome is affected by surface learning motivation; and
- the two effects above interact with each other, in relation to each type of learning outcome.

Part 2: The effect of interaction between self-rated competence in using computers and academic self-concept (general) on learning outcomes

It is expected that:

- each type of learning outcome is affected by self-rated competence in using computers;
- each type of learning outcome is affected by academic self-concept (general); and
- the two effects above interact with each other, in relation to each type of learning outcome.

Part 3: The effect of interaction between self-rated competence in using computers and concentration (in learning) on learning outcomes

It is expected that:

- each type of learning outcome is affected by self-rated competence in using computers;
- each type of learning outcome is affected by concentration (in learning); and
- the two effects above interact with each other, in relation to each type of learning outcomes.

Null hypotheses

Part 1

There is no relationship between:

- each type of learning outcomes and the self-rated competence in using computers;
- each type of learning outcomes and surface learning motivation; and
- the two effects above, in relation to each type of learning outcomes.

Part 2

There is no relationship between:

- each type of learning outcomes and the self-rated competence in using computers;
- each type of learning outcomes and academic self-concept (general); and
- the two effects above, in relation to each type of learning outcomes.

Part 3

There is no relationship between:

- each type of learning outcomes and the self-rated competence in using computers;
- each type of learning outcomes and concentration (in learning); and
- the two effects above, in relation to each type of learning outcomes.

Results and discussion of data analyses

As the major interest of the study is the interaction between the effects of the two independent variables (i.e. a computer-specific variable and a learning-related variable) on learning outcomes, the main effect of each independent variable will not be treated as the focus of study. It is expected that the arrangement is not only time saving for the reporter and readers, but also avoids information redundancy. All the statistical findings to be reported below are obtained from two-way analyses. For reference to the relationships between the independent variables and learning outcomes, readers are advised to refer to the results reported in Section 3-1-5-1.

Part 1: The effect of interaction between self-rated competence in using computers and surface learning motivation on learning outcomes

Table T3-1-7: Results of 2-way ANOVAs investigating the interaction between self-rated competence in using computers and surface learning motivation on learning outcomes

Dependent variable(s)	Independent Variable(s) / Grouping variable(s) with N = 110	Significance
Maths attainment (u_o_zma)	Self-rated competence in using computers (COM)	.000
	Surface learning motivation (LMS)	.037
	Interaction of the two effects above (COM x LMS)	.013
Academic attainment (u_o_zaa)	Self-rated competence in using computers (COM)	.006
	Surface learning motivation (LMS)	.013
	Interaction of the two effects above (COM x LMS)	.049

Seven 2-way ANOVA models were examined in the data analysis. Significant interaction between the effects of the two independent variables was found in two of these models, at $p < .05$ level. The results reported in Table T3-1-7 and the mean statistics are described in Table T3-1-8 and Table T3-1-9. The mean statistics are further presented in Illustration I3-1D and Illustration I3-1E. As the interaction between the effects of the two independent variables was not found to be statistically significant in any other models, other details of the results will not be reported in the text below. All the results to be reported are statistically significant.

Table T3-1-8: Means of pupils' maths attainment in the following research conditions

	Low competence computer users (COM = 1)	High competence computer users (COM = 2)	T-test: Significance of difference between the two conditions (COM = 1 & COM = 2)
Low surface learning motivation (LMS = 1)	45.26	54.60	.000
High surface learning motivation (LMS = 2)	45.85	47.94	.322

Table T3-1-9: Means of pupils' academic attainment in the following research conditions

	Low competence computer users (COM = 1)	High competence computer users (COM = 2)	T-test: Significance of difference between the two conditions (COM = 1 & COM = 2)
Low surface learning motivation (LMS = 1)	46.86	53.46	.001
High surface learning motivation (LMS = 2)	46.13	47.22	.585

In each of the tables, the effects of self-rated competence in using computers is large among pupils with low surface learning motivation and the effects of self-rated competence in using computers is small or insignificant among pupils with high surface learning motivation.

Illustration I3-1D: Interaction between COM & LMS
(Y-axis: means of maths attainment)

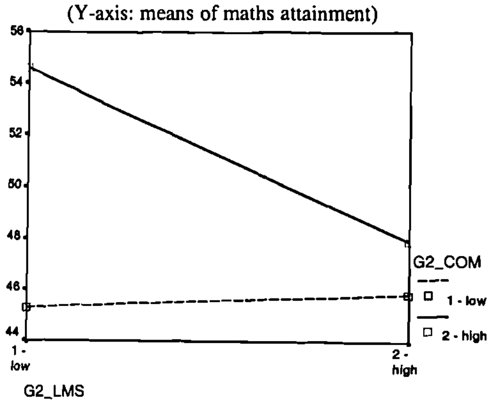
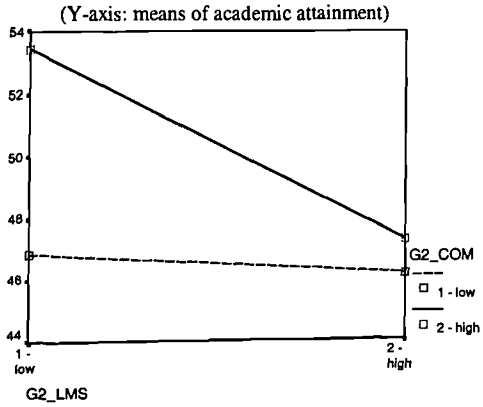


Illustration I3-1E: Interaction between COM & LMS
(Y-axis: means of academic attainment)



Furthermore, two t-tests were carried out to examine the differences between the two research conditions. Among pupils with high surface learning motivation, there was no significant difference between high competence computer users and low competence computer users in terms of the means of pupils' maths attainment and their academic attainment, respectively at $p < .05$ level. Among pupils with low surface learning motivation, significant difference between the two conditions was found, at $p < .05$ level. Both tables showed that among pupils with low surface learning motivation, those who were highly competent in using computers had better attainment than those who were not highly competent in using computers.

It appears that pupils with low surface learning motivation can be sub-divided into two contrasting groups. One of the groups was comprised of pupils who wanted to use the computers not only for fulfilling minimum learning requirements, but also for other intrinsic reasons e.g. to cope with the developmental pace among their peers, to gain experience. Another group was comprised of pupils who were not interested in studying or in using the computers. Further t-tests analyses showed that the former group also had better concentration in learning, better academic self-concept and higher usage of concrete experience learning orientation than the latter group, at $p < .05$ level. The features about the group seem to be consistent.

Since a series of seven learning outcome measures was used in the analysis, the percentage of significant results out of the total number of trials were compared to the requirement of the test of significance for a series of exploratory statistical analysis proposed by Sakoda et. al. (1953). The examination showed that the findings were statistically strong enough to be accepted at $p < .05$ level. Therefore, the results are not likely to have happened by chance.

Part 2: The effect of interaction between self-rated competence in using computers and academic self-concept (general) on learning outcomes

Table T3-1-10: Results of 2-way ANOVAs investigating the interaction between self-rated competence in using computers and academic self-concept on learning outcomes

Dependent variable(s)	Independent Variable(s) / Grouping variable(s) with N = 110	Significance
maths learning gains (u_r_zma)	Self-rated competence in using computers (COM)	.038
	Academic self-concept (AC)	.000
	Interaction of the two effects above (COM x AC)	.026
Academic learning gains (u_r_zaa)	Self-rated competence in using computers (COM)	.421
	Academic self-concept (AC)	.000
	Interaction of the two effects above (COM x AC)	.034

Seven 2-way ANOVA models were examined in the data analysis. Significant interaction between the effects of the two independent variables was found in two of these models, at $p < .05$ level. The results reported in Table T3-1-10 and the mean statistics are described in Table T3-1-11 and Table T3-1-12. The mean statistics are further presented in Illustration I3-1F and Illustration I3-1G. As the interaction between the effects of the two independent variables was not found to be statistically significant in any other models, other details of the results will not be reported in the text below. All the results to be reported are statistically significant.

Table T3-1-11: Means of pupils' maths learning gains in the following research conditions

	Low competence computer users (COM = 1)	High competence computer users (COM = 2)	T-test: Significance of difference between the two conditions (COM = 1 & COM = 2)
Low academic self-concept (AC = 1)	-5.03	.25	.004
High academic self-concept (AC = 2)	2.21	2.00	.909

Table T3-1-12: Means of pupils' academic learning gains in the following research conditions

	Low competence computer users (COM = 1)	High competence computer users (COM = 2)	T-test: Significance of difference between the two conditions (COM = 1 & COM = 2)
Low academic self-concept (AC = 1)	-4.48	-1.34	.044
High academic self-concept (AC = 2)	2.96	1.53	.339

Illustration I3-1F: Interaction between COM & AC (Y-axis: means of maths learning gains)

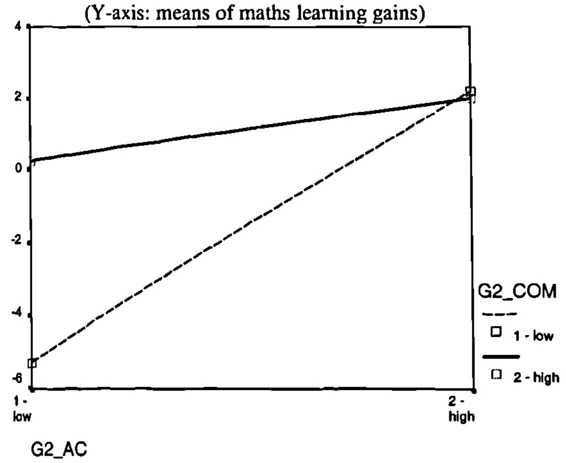
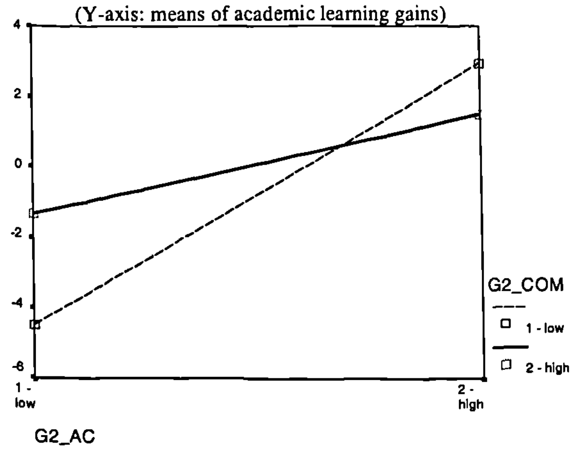


Illustration I3-1G: Interaction between COM & AC (Y-axis: means of academic learning gains)



In each of the tables, two t-tests were carried out to examine the differences between the two research conditions. Among pupils with high academic self-concept, no significant difference between high competence computer users and low competence computer users in terms of the means of pupils' maths learning gains and their academic learning gains, respectively at $p < .05$ level. Among pupils with low academic self-concept, significant difference between the two conditions was found, at $p < .05$ level. Both tables showed that among pupils with low academic self-concept, those who are highly competent in using computers had better learning gains than those who are not.

It appears that pupils with low academic self-concept can be sub-divided into two contrasting groups. One of the groups comprises pupils with high self-rated competence in using computers, although the possession of computer skills and knowledge did not give much help to improve their academic self-concept. In other words, their self-concept concerning using computers was high although their academic self-concept was low. Another group was comprised of pupils with low self-rated competence in using computers and with low expectation of their academic performance or ability. The former group could be typically described as active computer users, while the latter group could be described as non-active computer users. Further t-tests analyses showed that the former group also had higher achievement motivation, higher appreciation of software interactivity, higher usage of active experimentation learning orientation and higher usage of concrete experience learning orientation than the latter group, at $p < .05$ level.

Two t-tests were carried out to examine the differences between the two research conditions. Among pupils with high academic self-concept, no significant difference between high competence computer users and low competence computer users in terms of the means of pupils' maths learning gains and their academic learning gains, respectively at $p < .05$ level. Among pupils with low academic self-concept, a significant difference between the two conditions was found, at $p < .05$ level. This implies that there is potential value in using computers to improve the maths learning gains and academic learning gains for pupils with low academic self-concept, provided that they had good IT skills.

Having said that, readers are advised not to neglect the possibility that the link between self-rated competence in using computers and learning outcome among pupils with low academic self-concept could have nothing to do with the use of computers. Although it seems unlikely, the possibility of measurement error is still existed. For example, high self-rated competence in using computers could be interpreted as high in academic self-concept in information technology. Pupils who have low academic self-concept and high self-rated competence in using computers have a higher general academic self-concept (i.e. academic self-concept in information technology) than pupils who have low academic self-concept and low self-rated competence in using computers. On the basis of this, the result will be interpreted as a link between academic self-concept and learning outcome, which might not relate to the use of computers.

Since a series of seven learning outcome measure was used in the analysis, the percentage of significant results out of the total number of trials were compared to the statistical requirement for a series of exploratory statistical analysis proposed by Sakoda et. al. (1953). The examination showed that the findings were statistically strong to be accepted at $p < .05$ level. Therefore, the results are not likely to have happened by chance.

Part 3: The effect of interaction between self-rated competence in using computers and concentration (in learning) on learning outcomes

Table T3-1-13: Results of 2-way ANOVAs investigating the interaction between concentration in learning and self-rated competence in using computers on learning outcomes

Dependent variable(s)	**Independent Variable(s) / Grouping variable(s) with N = 110**	**Significance**
non-verbal ability (u_o_zpp)	Self-rated competence in using computers (COM)	.034
	Concentration in learning (LCN)	.582
	Interaction of the two effects above (COM x LCN)	.045

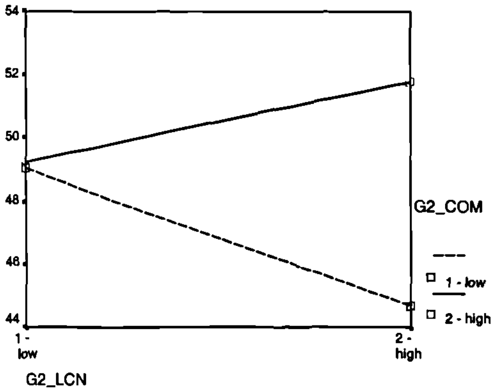
Seven 2-way ANOVA models were examined in the data analysis. A significant interaction between the effects of the two independent variables was found, at $p < .05$

level. The results reported in Table T3-1-13 and the mean statistics are described in Table T3-1-14. The mean statistics are further presented in Illustration I3-1H. As the interaction between the effects of the two independent variables was not found to be statistically significant in any other models, other details of the results will not be reported in the text below.

Table T3-1-14: Means of pupils' results in problem of positions test in the following research conditions

	Low competence computer users (COM = 1)	High competence computer users (COM = 2)	T-test: Significance of difference between the two conditions (COM = 1 & COM = 2)
Low concentration (LCN = 1)	49.04	49.23	.929
High concentration (LCN = 2)	44.65	51.75	.010

Illustration I3-1H: Interaction between COM & LCN
(Y-axis: mean scores of non-verbal ability test)



In the table, two t-tests were carried out to examine the differences between the two research conditions. Among pupils with low concentration, there was no significant difference between high competence computer users and low competence computer users in terms of the means of pupils' scores in problem of positions test, at $p < .05$ level. Among pupils with high concentration, a significant difference between the two conditions was found, at $p < .05$ level. Among these pupils, those who are highly competent in using computers had higher non-verbal ability in problem of positions task than those who are not highly competent in using computers. It appears that pupils who have high concentration can be sub-divided into two contrasting groups. One of the groups was comprised of pupils who had established self-rated competence in using the computers, while another group was comprised of pupils who did not have the self-rated competence in using the computers. The results suggested that the effects of self-rated competence in using computers depend on pupils' concentration in learning. The effects could be greatly hindered by low concentration.

Since a series of seven learning outcome measure was used in the analysis, the percentage of significant results out of the total number of trials was compared to the requirement of the test of significance for a series of exploratory statistical analysis proposed by Sakoda et. al. (1953). The examination suggested that the results are not statistically strong enough to be accepted at $p < .05$ level.

Implications and potential contributions

The results of this study show the inter-relationships between computer-specific variables and other learning-related variables. Most of the research concerning the use of computers considered only the benefits and pedagogical implications that computers can bring, while its impact on other learning-related variables were greatly ignored. Learning is a complex system. It would be meaningless to make a pedagogical decision aiming for maximising the direct effects that computers may bring, while its indirect effects were greatly ignored. Therefore, to aim for an effective use of computers, we need to consider the effects of some computer-specific variables, some other learning-related variables as well as the interaction effects between these two types of variable.

(3-2) Further consideration of learning supported by the computer and its effectiveness: In-school and out-of-school learning with the use of computers, subject preference, grouping and gender difference in computer-related learning tasks, and learning outcome

In this section, the author of this thesis reports three studies about effective learning supported by the computer. In the first study, the author investigates the in-school and out-of-school usage of computers for learning purposes, gender difference and learning outcomes. Their links with issues about gender difference and the effectiveness of time spent on the computer will also be addressed. The second study is on the relationships between subject preference, the use of computers to support subject learning, gender difference and learning outcomes. The third study is about grouping for learning tasks with the use of computers, subject preference and subject learning outcomes.

Sampling, data collection and data treatment

The data were collected from the administration of two pupil questionnaires. The class teacher was responsible for the administration of the questionnaires. On the date when each of the two questionnaires was carried out, all the pupils in class were involved in the survey. The first questionnaire was administered immediately after the questionnaire in section 3-1 was completed. The sampling was exactly the same as for the questionnaire mentioned in section 3-1, with the exception of 24 pupils in a Year 6 class. So, the data was collected from 229 pupils from 3 schools. The collected data provided sociometric information from pupils in 10 primary classes. It included five

Year 4 classes, four Year 5 classes and one Year 6 class. About 52% of the pupils were involved in the TTAICT project for computer-related development when the questionnaire was administered.

The second questionnaire was administered in May 1999. This was a sub-sample of the classes that were involved in the questionnaire mentioned in section 3-1. The data were collected from 166 pupils from 2 schools. The first school was a large school and the second school was a school where pupils were mainly from advantaged backgrounds, as mentioned in section 3-1 above. A total of 106 pupils were from the first school and 60 pupils were from the second school. The data were collected from two year 4 classes and two Year 5 classes of the first school and from a Year 4 class and a Year 6 class of the second school. About half of the pupils were involved in the TTAICT project for computer-related development when the questionnaire was administered. Nevertheless, value-added data obtained from PIPS was also used for this study. Further detail about this can be found in Chapter 2.

(3-2-1) In-school and out-of-school learning with the use of computers, gender difference in time spent on computer-related learning tasks and learning outcome

Description of the issues to be addressed

Nowadays, using computers for learning purposes is not only restricted to classrooms at school. Computers can be available for learning in some other places outside school. For instance, a child may have access to the computer at home, at a friend's house and/or at many public libraries. It is possible for a child who does not have a computer at home to have access to a computer in other places for out-of-school learning. In line with this, McFarlane (1997) states that "gender and out-of-school experience are both important factors relating to a child's access to IT".

The results of recent survey of ICT equipment show that a high proportion of the computer-related equipment in primary schools in UK is outdated (McKinsey and Company, 1997) and incompatible with latest software application. This will adversely affect the frequency and the opportunity for pupils to have a turn on the computer at school for learning purposes. In contrast, some children may find it easier to get access to the computers during their out-of-school time than school time. It might be worthwhile to investigate if it generally applies to the Year 4 to 6 pupils involved in this study.

This study will compare the amount of time that pupils spent on the computer at school and on the computer outside school. This is followed by an investigation of their potential links with measures of learning outcome, and whether there is any gender difference in the amount of time spent on the computer at school or outside school. The issue of gender difference is considered here because it is an aspect of pupil characteristics. In a literature review, Brosnan (1998) stated that boys at the age of primary education had a more positive attitude towards computers than girls had. The author warned that computers could be motivationally problematic for girls. It might be worthwhile to see if there was any gender difference in terms of time spent on the computers when pupils were at school and outside school.

Furthermore, this section will report the results of a survey on the main focuses of out-of-school usage of computers. The main types of curriculum usage of the computer(s) at school will not be addressed here. It is believed that it might be more appropriate to address this issue from a teacher's perspective, to be reported in Chapter 4.

Research hypotheses and research methods

It was expected that:

1. pupils in this study (Year 4 to 6) would spend longer time on the computer outside school than on the computer at school;
2. there would be a gender difference between the amount of time spent on the computer at school, but there would be a gender difference between the amount of time spent on the computer outside school; and
3. the two measures of amount of time on the computer (i.e. mentioned in hypothesis 1 above) would be related to measures of learning outcome.

The first and the third research hypotheses were investigated through the use of t-test statistics. The second research hypothesis was investigated through the use of correlation tests. The data used in this study were based on pupils' response to the two questionnaires, as mentioned above.

Results and discussion

The results of descriptive statistics show that the pupils in the study spent about 1.42 hours on the computer at school in a week's time, while they spent about 2.42 hours on the computer(s) outside school. The results of paired t-tests show that there was a significant difference between the two at $p < .05$ level (two-tailed) and with N=154. No gender difference was found in terms of the amount of time spent on the computer at school or the amount of time spent outside school, at $p < .05$ level (two-tailed) and with N=163 and N=154, respectively. This means that pupils spent more time on computers outside school than on the computer(s) at school. Such a difference applies to boys as well as girls.

The next investigation is focused on the pattern of usage of computers outside school. The results are summarised in Table T3-2-1. The results of descriptive statistics show that about half of the pupils used computers both for games and for learning purposes. The results apply to boys and girls. Nevertheless, the results suggest that using computers outside school for games and leisure purposes was a common usage among pupils, including boys and girls. If we assume that focus of usage of the computer(s) at school is mainly for learning and teaching purposes (i.e. further detail about curriculum use of computers can be found in Chapter 4, section D2-2), the use of computers outside school for games or leisure purposes can be regarded as an experience that pupils do not normally have (or rarely have) when working with the computer(s) at school.

Table T3-2-1: Pupils' responses to the item "When you are not at school (e.g. at home), what do you normally use the computer for?"

	Not using it at all	Mainly for games	For games and learning	Mainly for learning
Girls	17.9%	17.9%	54.8%	9.5%
Boys	14.6%	26.8%	46.3%	12.2%
All	16.3%	22.3%	50.6%	10.8%

Remark: Total number of pupil respondents equals to 166. Among them, there are 82 boys and 84 girls.

Finally, an investigation is carried out into the relationship between the two measures of amount of the computer use and measures of learning outcome. The results of correlation tests show that none of the two measures of the amount of time spent on computers is related to any measures of learning outcome at $p < .05$ level (two-tailed) and with N=36 to 44. The measures of learning outcome include pupils' maths/reading attainment, their maths/reading gains, their attitude toward maths/reading/school, the measure of picture vocabulary and the measure of ability in handling problems of position. Having said that, it might be too early to conclude that the use of computers at school or outside school is not related to learning. Alternatively, the results may mean that the relationships between them are complex. For instance, an effective learning and teaching environment supported by computers is determined by the simultaneous operation of a group of variables. The amount of time on the computer, including in-school and out-of school usage of computers, is only one of the variables affecting the effectiveness of use. Attention needs to be paid to the co-ordination or interactions between these variables, not just focusing on the extent of usage alone.

(3-2-2) Subject preference in computer-related learning tasks, school learning with the use of computers, gender difference in attitude towards learning tasks with/without computers and learning outcome

The issues to be addressed

In this section, we shall look at the use of computers to support the learning and teaching of different subjects. The main concern is the difference between the use of computers for maths and for language learning and teaching. Generally speaking, maths mainly deals with numbers and literacy mainly deals with text. There is a range of ICT activities to support for the learning of these subjects.

Ng (1996) has outlined four major approaches in information technology-aided language instruction. These include:

"

- telecommunication-mediated writing - computers, and their users, separated by great distances, can be connected (i.e. networked) through telephone lines to permit exchange of messages and ideas e.g. email, electronic conferencing;
- word processor-facilitated composition - it uses a technology that is commonly available in schools. The use of word processors to assist writing is one of the most widely explored technology-based approaches in education;
- hypermedia-supported language learning - it refers to the combination of multimedia and hypertext. Users can move from one piece of information to

another via a multitude of paths, and can impose and construct their own information structure e.g. by adding links and new information; and

- simulation-stimulated oral discourse - they involve adopting roles and making decisions within well-defined human situations for the purpose of exploring social, ethical, or economic principles and dealing with constraints. For example, presenting a scenario and either place the user(s) in different roles to explore various responses or solicit decisions regarding a set of variables to produce the best desirable outcome.

(adapted from Ng, 1996, page 556)"

Besides the list above, there are also other kinds of language-related computer activities. For example, talking electronic books and word-related problem-solving activities. In primary classrooms, perhaps the most typical type of usage of computers for language learning is the word processor-facilitated compositions and simulations (i.e. refer to the results of a survey of curriculum usage of ICT in Chapter 4, Section D2-2). In contrast, Olive (1996) has outlined five major types of computer software usage in maths education. These include:

"

- mathematical toolkits - include multipurpose tools such as calculators, spreadsheets, and graphing utilities, and powerful mathematical computational environments such as Theorist and Mathematica;
- catalysts - include conjecturing tools such as the Geometer's Sketchpad, exploratory microworld environments, and tools for representing and manipulating mathematical relations;

- formal language interfaces - they can be powerful and accessible programming environments (e.g. LOGO) which give teachers and students the power to engage in algorithmic problem-solving, and to create their own computer-based learning environments and mathematical tools;
- tutorials - they are mainly drill and practice environments designed to reinforce learning skills; and
- hypemedia - it cuts across all the four categories above. It can provide easy access to other media and information sources such as videodisks, CD-ROM, remote database, and other software application tools.

(adapted from Olive, 1996, page 546)"

In primary classrooms, perhaps the most common type of usage of computers for learning maths is the fourth category above (i.e. refer to the results of a survey of curriculum usage of ICT in Chapter 4, Section D2-2). The use (or not use) of calculators is a controversial issue because improper usage of the technology may have negative impact on learning. It is argued that calculators should be banned because they perform the calculation for the children and they reduce the opportunities for them to learn and practise.

The major interest in this study is on pupils' attitude towards the subject with the use or without the use of computers for learning. This study looks at the links and the difference between the two subjects at two levels. At the between-subject level, some learners have a high motivation to learn and some learners have low motivation. Some learners have a positive attitude towards learning with computers and some learners do not. It is possible that learners' attitude towards one subject is linked with their attitude towards another subject. Similarly, it is possible that learners' attitude towards the use of computers for maths learning is linked with their attitude towards the use of computers for language learning. Gender difference is an example of between-subject difference.

Research hypotheses and research methods

It was expected that:

1. there would be a link and a difference between pupils' attitude toward different subjects (i.e. English and maths) of the primary curriculum;
2. there would be a link and a difference between their attitude toward different subjects (i.e. English and maths) when the computer was used to support the subject learning;
3. the effect of subject preference would interact with the effect of using computers for subject learning;
4. there would be a gender difference in relation to the hypothesis 3 above; and
5. there would be a link between learning outcome and the relative preference towards learning with computers as an opposition to learning without computers.

The first three hypotheses were investigated by t-test statistics and correlation statistics with the use of pupils' responses to item 4 to item 7 of the pupil questionnaire presented in Appendix 3-B. The last hypothesis was investigated by a two-way ANOVA with the use of pupils' response to item 4 to item 7 as dependent variables. The two independent variables were named as "subject preference" and "using computers for subject teaching".

Finally, this study also tried to investigate the potential link between the actual difference in attitude between using and not using computers for learning maths/English and measures of learning outcome. The "actual difference in attitude between using and not using computers for learning maths" was computed by pupils' responses to item 7 minus their responses to item 6. The "actual difference in attitude between using and not using computers for learning English" was computed by pupils' responses to item 5 minus their responses to item 4. Measures of learning outcome consist of 10 outcome variables in PIPS. They are:

- pupils' maths attainment,
- pupils' reading attainment,
- pupils' maths gains,
- pupils' reading gains,
- pupils' attitude towards maths,
- pupils' attitude towards reading,
- pupils' attitude towards school,
- pupils' scores in problem of position tasks (non-verbal ability),
- pupils' scores in picture vocabulary tasks (verbal ability), and
- pupils' home background measure.

Correlation statistics were used for the investigation. Gender difference was also taken into consideration.

Results and discussion

The results show that pupils' attitude toward English lessons was not correlated with attitude toward maths lessons, at $p < .05$ level (two-tailed) and with N= 160. Attitude toward English lessons when using a computer was correlated with attitude toward maths lessons when a computer was used, at $p < .01$ level (two-tailed) and with N=132. The Pearson correlation statistic (r) was 0.30. The results of paired t-test shows that the extent of positive attitude toward English lessons was significantly less than that toward maths lessons, at $p < .01$ level (two-tailed) and with N= 160. The means are 3.66 and 4.04. It means that pupils' attitude toward English lessons is between "not sure" and "like them" and their attitude toward maths lessons is "like them". No significant difference was found between pupils' attitude toward English lessons when using a computer and their attitude toward maths lessons when using a computer, at $p < .05$ level (two-tailed) and with N=132.

Pupils' attitude toward English lessons was correlated with their attitude toward English lessons when using a computer, at $p < .01$ level and with N=158. The Pearson correlation statistic (r) was 0.29. The results of paired t-test indicate that the former was lower than the latter, with the means of 3.65 and 4.45, respectively. It means that pupils' attitude toward English lessons was between "not sure" and "like them" and their attitude toward English lessons when using computers was between "like them" and "love them". Their attitude toward maths lessons was correlated with attitude toward maths lessons when using a computer, at $p < .01$ level and with N = 136. The Pearson correlation statistic (r) was 0.26. The results of paired t-test results indicate that the former was lower than the latter, with means of 3.93 and 4.36, respectively. It means that pupils' attitude toward maths lessons was "like them" and their attitude toward maths lessons when using computers was between "like them" and "love them".

The results lead to the generalisation that the effects of subject preference become insignificant when the computer is being used to support the subject learning and teaching. A two-way ANOVA was carried out to examine the generalisation. The results are summarised in Table T3-2-2. The interaction effect between "subject preference" and "using computers for subject learning" is statistically significant at $p < .05$ level (two-tailed) and with $N = 129$. The results indicate that the effect of "subject preference" depends on the use of computers. As mentioned above, in normal subject learning, the effect of "subject preference" is statistically significant. When the computer is used for subject learning, the effect of "subject preference" becomes insignificant.

Table T3-2-2: Results of two-way ANOVA (two-tailed) investigating the relationships between subject preference and the use of computers for subject learning

Factor	Sum of squares	Df	Mean squares	F-statistic	Sig.
Main effect of "subject preference"	2.95	1	2.95	2.32	.130
Error (effect of "subject preference")	162.80	128	1.27		
Main effect of "using computers for subject learning"	51.49	1	51.49	52.20	.000
Error (effect of "using computers for subject learning")	126.26	128	.99		
Interaction effect between "subject preference" and "using computers for subject learning"	5.04	1	5.04	5.78	.018
Error (interaction effect)	111.71	128	.87		

Remark: The data are collected from 129 pupils. The mean statistics are reported in Table T3-2-5.

The gender issue is investigated through two ANOVAs. The first one is done with the data collected from boys, while the second one is done with the data collected from girls. The results are reported in Table T3-2-3 and Table T3-2-4. The mean statistics of the two ANOVAs and the mean statistics of the ANOVA above are reported in Table T3-2-5.

Table T3-2-3: Results of two-way ANOVA (two-tailed) investigating the relationships between subject preference and the use of computers for subject learning among the boys in this study (Year 4 to 6)

Factor	Sum of squares	df	Mean squares	F-statistic	Sig.
Main effect of "subject preference"	11.29	1	11.29	11.04	.001
Error (effect of "subject preference")	67.46	66	1.02		
Main effect of "using computers for subject learning"	29.56	1	29.56	25.27	.000
Error (effect of "using computers for subject learning")	77.19	66	1.17		
Interaction effect between "subject preference" and "using computers for subject learning"	4.06	1	4.06	4.08	.047
Error (interaction effect)	65.69	66	1.00		

Remark: The data are collected from 67 boys. The mean statistics are reported in Table T3-2-5.

The results reported in Table T3-2-3 show that the effect of subject preference and the effect of using computers are statistically significant at $p < .05$ level (two-tailed), with N=67. The interaction between the two effects is also statistically significant at $p < .05$ level. It means that boys like lessons with computers more than lessons without computers. They also like maths lessons more than English lessons, however, such a difference becomes statistically insignificant when computers are used. In other words, there is no significant difference between their attitude toward maths lessons with computers and English lessons with computers (i.e. the results of t-test at $p < .05$ level and with N=69).

Table T3-2-4: Results of two-way ANOVA (two-tailed) investigating the relationships between subject preference and the use of computers for subject learning among the girls in this study (Year 4 to 6)

Factor	Sum of squares	Df	Mean squares	F-statistic	Sig.
Main effect of "subject preference"	1.03	1	1.03	.73	.395
Error (effect of "subject preference")	85.97	61	1.41		
Main effect of "using computers for subject learning"	22.08	1	22.08	27.53	.000
Error (effect of "using computers for subject learning")	48.92	61	.80		
Interaction effect between "subject preference" and "using computers for subject learning"	1.31	1	1.31	1.74	.192
Error (interaction effect)	45.69	61	.75		

Remark: The data are collected from 62 girls. The mean statistics are reported in Table T3-2-5.

The results reported in Table T3-2-4 show that the effect of using computers is statistically significant at $p < .05$ level (two-tailed), with N=62. The effect of subject preference and the interaction between the effects of using computers and subject preference are not statistically significant at $p < .05$ level (two-tailed) with N=62. It means that similar to boys, girls also like lessons with computers more than lessons without computers. They also like English lessons with computers more than maths lessons with computers (i.e. supported by the results of paired t-test at $p < .05$ level and with N=63), however, such a difference becomes statistically insignificant when computers are not used. In other words, there is no significant difference between their attitude toward maths lessons and English lessons (i.e. the results of t-test at $p < .05$ level and with N=81).

Table T3-2-5: Mean statistics of three ANOVAs analysing subject preference, the use of computers and gender difference

	English lessons(Q4)	English lessons with computers (Q5)	maths lessons (Q6)	maths lessons with computers (Q7)
All	3.57	4.40	3.92	4.36
Boys	3.30	4.21	3.96	4.37
Girls	3.87	4.61	3.89	4.34

Remark/Keys: The data are collected from 129 pupils. Among them, there are 67 boys and 62 girls. In the questions above, the response "I hate them" is coded as 1. The response "I don't like them" is coded as 2. The response "Not sure" is coded as 3. The response "I like them" is coded as 4. The response "I love them" is coded as 5.

The results suggest that the use of computers have significant impact on the effect of subject preference among the boys. The use of computers makes boys change their relative preference from maths to English. Such a difference becomes insignificant when computers are used for the subject learning and teaching. In contrast, no significant difference in subject preference is identified from girls. When computers are used, girls prefer English lessons with computers to maths lessons with computers. This leads to an investigation of the significance of the interaction between subject preference, the use of computers and gender difference with the same set of dependent variables. A 3-way ANOVA was carried out. The interaction effect is not found to be statistically significant at $p < .05$ level (two-tailed) with N=129. That means the results of data analysis has failed to demonstrate that the significance of the interaction effect between subject preference and the use of computers for subject learning and teaching is affected by gender difference. To sum up, the results suggest that the effect of subject preference interacts with the effect of using computers for subject learning and teaching, however, careful consideration should be given to the gender difference.

The last investigation is into the effects of the attitude (or preference) towards using (or not using) computers for learning maths or English on pupils' learning outcomes. Two series of correlation statistics are computed. Each of them contains the ten outcome measures above. The significant Pearson correlation statistics (r) are reported as below, with ** refers to $p < .01$ level and * refers to $p < .05$ level:

- pupils' relative preference toward learning maths with computers as an opposition to learning maths without computers & their maths attainment (r = -0.41**, with N=42),
- pupils' relative preference toward learning maths with computers as an opposition to learning maths without computers & their attitude toward reading (r = 0.36*, with N=43), and
- pupils' relative preference toward learning maths with computers as an opposition to learning maths without computers & their score in picture vocabulary tasks (r = 0.36*, with N=44).

Three significant findings out of ten statistical tests have satisfied the requirement of the test of significance for a series of statistical tests at $p < .05$ level suggested by Sakoda et. al. (1953). It is unlikely that the relationship happened by chance. No significant correlation between pupils' relative preference toward learning English with computers (i.e. as an opposition to learning English without computers) and their learning outcome were statistically significant at $p < .05$ level, with N=37 to 40. The results mean that pupils who are in favor of using computers for learning maths tend to have:

- lower maths attainment,
- positive attitude towards reading,
- higher scores in picture vocabulary tasks, and vice versa.

No significant correlation between pupils' relative preference attitude towards learning English with computers and their learning outcome was found at $p < .05$ level, with N=37 to 40.

To consider the issue of gender difference, two series of correlation statistics were computed with data collected from the boys and from the girls, respectively. No significant association is found when data collected from the girls are used, with N=16 to 19. The only exception is a significant association between girls' relative preference toward learning English with computers (i.e. as an opposition to learning English without computers) and their average learning gains (i.e. average of maths gains and reading gains) at $p < .05$ level, and with N=16. The finding can be regarded as a chance effect because one significant finding out of ten statistical tests does not have satisfied the requirement of the test of significance for a series of statistical tests at $p < .05$ level suggested by Sakoda et. al. (1953).

In contrast, significant associations are found when data collected from the boys were used, with N=22 to 25. The significant Pearson correlation statistics (r) are reported as below, with ** refers to $p < .01$ level and * refers to $p < .05$ level:

- boys' relative preference toward learning English with computers as an opposition to learning English without computers & their maths attainment (r = 0.48*, with N=23),
- boys' relative preference toward learning English with computers as an opposition to learning English without computers & pupils' reading attainment (r = 0.50*, with N=23),
- boys' relative preference toward learning English with computers as an opposition to learning English without computers & pupils' scores in problem of position tasks (r = 0.61**, with N=22),
- boys' relative preference toward learning maths with computers as an opposition to learning maths without computers & pupils' maths attainment (r = -0.53**, with N=24),
- boys' relative preference toward learning maths with computers as an opposition to learning maths without computers & pupils' attitude toward reading (r = 0.47*, with N=24), and
- boys' relative preference toward learning maths with computers as an opposition to learning maths without computers & pupils' scores in picture vocabulary tasks (r = 0.52**, with N=25).

Three significant findings out of ten statistical tests have satisfied the requirement of the test of significance for a series of statistical tests at $p < .05$ level suggested by Sakoda et. al. (1953). It is unlikely that the relationships identified from each of the two series of correlation tests are happened by chance. The results mean that boys who are in favor of using computers for learning English tend to have:

- lower maths attainment,
- higher reading attainment,
- higher scores in problem of position tasks, and vice versa.

Boys who are in favour of using computers for learning maths tend to have:

- lower maths attainment,
- positive attitude towards reading,
- higher scores in picture vocabulary tasks, and vice versa.

As the focus is on the gender difference, no attempt is made to find out possible explanations for the results above. Instead, it is obvious that there is a gender difference in the number of significant links (i.e. positive and negative links) between pupils' relative preference toward learning with computers and learning outcome. To the boys in the study, it is obvious that there are significant links between the two, both in learning English and learning maths. To the girls in the study, no links between their relative preference toward learning Maths with computers (i.e. as an opposition to learning maths without computers) and learning outcome were found. Having said that, with the exception mentioned above, it is inappropriate to rule out the possibility of the presence of links between girls' relative preference toward learning English with computers (i.e. as an opposition to learning English without computers) and learning outcome. As the sample size of the present study is small, further research evidence is needed before a decision on the issue can be made.

(3-2-3) Grouping and gender difference in computer-related learning tasks, subject preference in computer-related learning tasks and subject learning outcome

In this section we will report three studies of grouping on computer-related learning tasks. The first one reports the result of a survey of the best size of grouping for learning tasks with the use of computers and subject preference. The second one addresses gender difference and subject preference in uni/mixed- grouping choice for learning tasks with the use of computers on the basis of the results of descriptive statistics. The third one investigates the relationships between subject learning outcomes, popularity as partners in learning task with the use of computers and the characteristics associated with it.

(3-2-3-1) The best size of grouping and subject preference in computer-related learning tasks

The issues to be addressed and research method

Do children perform better when working alone with the computer or working in a group with the computer? When children are working in a group with the computer, what is the optimum group size?

To answer these questions from the pupils' perspective, a survey was carried out with the use of the last two questions in section 2 of the pupil questionnaire presented in Appendix 3-B.

Results and discussion

The optimum group size for working with the computer is working in pairs. The details of the results are reported in Table T3-2-6. The results of descriptive statistics show that in English lessons and maths lessons with the use of computers, pupils consistently think that they learn best when they are working in pairs. The results might mean the importance of learning through interaction. In referring to the "model of learning and teaching processes" in section 3-1, a pair work activity with the use of a computer would likely include the interaction between two pupils and the interaction between the pupil(s) and the computer.

From the perspective of problem-based learning, the learning task on the computer is the target of their work. To tackle the learning problem or to achieve the learning target(s), pupils often perceived the value of working collaboratively together. In English lessons, communication is a major function of language. Talking between pupils when working on a language learning task supported by the computer can be very useful activity for their learning. When dealing with a maths problem on the computer, a pupil's talk about how he or she gets the correct answer may help his partner to understand the mathematical concepts to be used in the mathematical operation. The feedback provided by the computer also makes contributions to their learning.

The results also indicate that about 40% of the pupils viewed working alone as their first choice and about 23% of the pupils viewed it as their last choice. It means that there are pupils who think that they learn best when working alone, but there are pupils who don't think that they learn best when working alone. The choices that pupils made are affected by their preference toward collaborative learning. Beside this, their choices made could also be affected by their ability and/or their confidence to work alone with the task on the computer. Pupils who vote working alone as their first choice are likely to be people who are confident and/or capable enough on the task, while pupils who vote working alone as their last choice are likely to be people who are not confident and/or capable enough on the task.

Table T3-2-6: Results of the choice-received concerning the best size of grouping for learning tasks with the use of computers

Size of grouping	Mean of Choices received: Eng/Math	% of first choice received: Eng/Math	% of second choice received: Eng/Math	% of third choice received: Eng/Math	% of last choice received: Eng/Math
Alone	2.11/2.17	39%/41%	31%/26%	9%/8%	21%/25%
A pair	1.58/1.67	55%/49%	37%/40%	5%/8%	4%/4%
A group of 3-4	2.71/2.60	8%/12%	23%/23%	60%/59%	10%/6%
A group of 5-6	3.53/3.49	2%/4%	8%/8%	26%/24%	64%/65%
Total		*157/137*	*148/127*	*145/127*	*146/128*

Remark: The data are based on pupils' responses to the last two questions of the Pupil Questionnaire 3. The first choice was coded as "1". The second choice was coded as "2". The third choice was coded as "3" and the fourth choice was coded as "4".

Keys: "*Total*" refers to "total number of choices received".

Nevertheless, the results in the table clearly indicate that working in a group of 3-4 pupils and in a group of 5-6 pupils are the third and the last choices, respectively. The contribution of grouping towards learning slows down when the size of the grouping goes beyond that. This could be explained by various reasons. For examples, pupils may block each other from viewing the information on the computer screen or in lack of opportunity to participate in the learning task when the size of the grouping is large.

(3-2-3-2) Gender difference in uni/mixed-gender grouping preference and subject preference in computer-related learning tasks

The issues to be addressed

As the results indicate that pupils generally think that they learn best when working in pairs with the computer, it seems worthwhile to carry out further investigation into the gender composition of pairs. Basically, there are three types of composition. These include:

- two boys
- two girls, and
- a boy and a girl

In this study, the first two types are uni-gender pairs and the last type is a mixed-sex pair. At the primary school age, it might be widely expected that pupils generally feel happier and have a better learning in uni-gender groupings than in mixed-gender groupings. This study will investigate whether this hypothesis is valid when pupils work on learning tasks with the use of computers. Issues about subject preference and criteria for making judgement about learning will also be considered.

Research hypotheses and research methods

It was expected that, in an English or maths lesson with the use of computers for paired learning:

- pupils would be happier when working in a uni-gender pair than in a mixed-gender pair; and
- pupils would thought that they learn better in a uni-gender pair than in a mixed-gender pair.

The above hypotheses were made on the basis of the two criteria of making judgement about learning preference: the enjoyment of the group work process and the learning effectiveness (i.e. better quality of learning).

It was also expected that:

- pupils would be more willing to work in a mixed-gender pair when their judgements about learning are based on learning effectiveness than when their judgements about learning are based on enjoyment of the learning process, and
- there would be a gender difference and a difference in subject preference in the above hypothesis.

The hypothesis is investigated by the use of descriptive statistics and t-tests. To facilitate comparison, the results will also be expressed as a percentage.

Results and discussion

The results are reported in Table T3-2-7. It is clear that more pupils felt that they were happier when working in a uni-gender pair than in a mixed-gender pair, and more pupils thought that they learned better in a uni-gender pair than in a mixed-gender pair. The pattern of relationships applies to English lessons and maths lessons with the use of computers. The pattern of relationship also applies when pupils use the two criteria for making judgement about learning.

Table T3-2-7: Pupils' choices (in %) toward uni/mixed-gender grouping, subject preference and criteria for making judgement about learning

Gender group: Uni/mixed-gender grouping choice made by pupils	Happier in English with computers	Happier in maths with computers	Better in English with computers	Better in maths with computers
Boys: uni-gender grouping	45%	45%	36%	36%
Boys: mixed-gender grouping	7%	8%	11%	17%
Girls: uni-gender grouping	43%	43%	40%	35%
Girls: mixed-gender grouping	5%	4%	13%	12%
Total number of choices:	165	159	125	121

Remark/Keys: The sampling is based on data collected from 166 pupils and the number of valid cases for each of the four items varies between 121 to 165.

For pupils of different sex, there was a big difference in their choices toward uni-gender grouping and mixed-gender grouping. However, the extent of difference varied when different criteria for making judgement about learning are used. When the criterion for making judgement about learning was based on the happiness of the working group, the extent of difference was very large. When the criterion for making judgement about learning was based on the quality of learning (i.e. better learning), the extent of difference was not as large as the former one.

The implication is that pupils are more willing to work in a mixed-gender group when they are aiming at better learning outcomes than when they are aiming at enjoyment during the group learning process, and vice versa. The pattern of relationship is clearly presented in Table T3-2-8. The results of mean statistics show that the choices made on the basis of learning effectiveness are consistently higher than the choices made on the basis of enjoyment during the learning process. The pattern of relationship applies to the boys and girls, and applies to maths lessons and English lessons. The relationship is supported by the significant differences found in four paired t-tests at $p < .01$ level or at $p < .05$ level and with N=56 to 81, as reported in Table T3-2-8.

Table T3-2-8: Results of mean statistics and t-tests concerning pupils' choices toward uni/mixed-gender grouping, subject preference and criteria for making judgement about learning

Gender group: Uni/mixed-gender grouping choice	Happier in English with computers	Better in English with computers	Happier in maths with computers	Better in maths with computers
Boys: uni/mixed-gender grouping	3.10	3.26	3.09	3.25
t-test (one-tailed)	significant at $p < .01$ level (N=77)		significant at $p < .01$ level (N=56)	
Girls: uni/mixed-gender grouping	3.14	3.22	3.16	3.31
t-test (one-tailed)	significant at $p < .05$ level (N=81)		significant at $p < .01$ level (N=61)	

Remark/Keys: The sampling is based on data collected from 166 pupils. The choice towards uni-gender grouping is coded as "3" and the choice towards mixed-gender grouping is coded as "4".

(3-2-3-3) Subject learning outcome, popularity as partners in computer-related learning tasks and the associated characteristics

The issues to be addressed

In this study, pupils who are popular in a learning task with the use of computers are those who are most welcomed by other pupils in a group setting when working on the learning task. As there is no research evidence (i.e. not found during this study) to suggest the presence or absence of a relationship between pupils' popularity as partners in computer-supported/assisted learning tasks and value-added learning outcomes, it was decided to investigate the issue. It is believed that there are many factors affecting popularity of this kind. Pupils' learning outcomes could be one of these factors, but there could be some more. Reasons for carrying out further studies of the characteristics associated with popularity of this kind are given in Part Two of this section.

Research hypotheses and research methods

It was expected that:

- there would be a relationship between a pupil's popularity as partners in a maths-related learning task with the computer and his/her learning outcomes in maths;
- there would be a relationship between a pupil's popularity as partners in a language-related learning task with the computer and his/her learning outcomes in reading; and
- there would be a relationship between a pupil's popularity as partners in a subject-specific learning task with the computer and his/her popularity as partners in any other aspects of learning.

The first two hypotheses were investigated by correlation statistics using value-added data obtained from PIPS and pupils' responses to question 8 and question 9 of the sociometric questionnaire, as presented in Appendix 3-C. It forms Part One of the study. The third hypothesis was investigated by two series of multiple regression analyses using pupils' responses to question 8 and question 9 of the sociometric questionnaire as dependent variables and using pupils' responses to other questions of the sociometric questionnaire as predictors. It forms Part Two of the study.

Results and discussion of Part One

The results of correlation statistics show that the number of choices received by pupils in reading and writing tasks on the computer was significantly related to their reading attainment and their reading gains at $p < .01$ and $p < .05$ level and with N=105 and 102, respectively. The Pearson correlation statistics are 0.27 and 0.20, respectively. The results of correlation statistics show that the number of choices received by pupils in number work on the computer was significantly related to their maths attainment at $p < .01$ and with N=106. The Pearson correlation statistics is 0.34. The results suggest that the first and the second hypotheses above are supported by the data. The fact that relationships are consistently positive mean that pupils with high popularity as partners in a computer-related learning task tend to have better learning attainment/gains, and vice versa. The low in the size of the association means that the link between popularity as partners in a computer-related learning task and achievement/progress in that subject is weak.

Results and discussion of Part Two

Results of the prediction of choice-received by a pupil as a partner in reading and writing tasks on the computer is reported in Table T3-2-9. The results suggest that 56% of the variance of the choice-received by a pupil as a partner in reading and writing tasks on the computer can be explained by the choice-received as a partner in number work with a computer. The percentage of variance increases when the number of predictors increases. The results show that 69% of the variance of the target variable is explainable by the simultaneous work of the four factors reported in the table. In the table, the Beta statistics show the size of the link between the target variable and each predictor. The information about statistical significance gives further support to the confidence about the size of the link. The two statistics indicate the relative importance of each of the predictors in explaining the variance of the target variable.

Table T3-2-9: Multiple regression models predicting choice-received by pupils in reading and writing tasks on the computer [Q8]

Predictor(s): Pupils choice-received... [Corresponding items on the sociometric survey]	R-square	Beta	Sig. of predictor	Sig. of ANOVA
...as a partner in number work with a computer [Q10]	.56	.75	.000	.000
...as a partner in number work with a computer [Q10]	.65	.45	.000	.000
...as a partner in e-mail discussion [Q11]		.43	.000	
...as a partner in number work with a computer [Q10]	.68	.33	.000	
...as a partner in e-mail discussion [Q11]		.40	.000	.000
...as best in using the computer [Q6]		.21	.000	
...as a partner in number work with a computer [Q10]	.69	.29	.000	
...as a partner in e-mail discussion [Q11]		.30	.000	.000
...as best in using the computer [Q6]		.24	.000	
...as best friend [Q4]		.17	.001	

Remark: The data are collected from 229 pupils. 'Stepwise' selection method is used.

Keys: "Q" refers to question item of the sociometric questionnaire.

Results of the prediction of choice-received by a pupil as a partner on the computer is reported in Table T3-2-10. The results suggest that 57% of the variance of the choice-received by a pupil as a partner in number work on the computer can be explained by the choice-received as a partner in number work without the use of computer. The percentage of variance increases when the number of predictors increases. The results show that 71% of the variance of the target variable is explainable by the simultaneous work of the five factors reported at the bottom of the table.

Table T3-2-10: Multiple regression models predicting choice-received by pupils in number work on the computer [Q10]

Predictor(s): Pupils choice-received... [Corresponding items on the sociometric survey]	R-square	Beta	Sig. of predictor	Sig. of ANOVA
...as a partner in number work [Q9]	.57	.76	.000	.000
...as a partner in number work [Q9]	.67	.46	.000	.000
...as a partner in reading and writing work with a computer [Q8]		.43	.000	
...as a partner in number work [Q9]	.70	.40	.000	.000
...as a partner in reading and writing work with a computer [Q8]		.34	.000	
...as best in using the computer [Q6]		.21	.000	
...as a partner in number work [Q9]	.71	.32	.000	.000
...as a partner in reading and writing work with a computer [Q8]		.34	.000	
...as best in using the computer [Q6]		.18	.000	
...as best in writing and spelling [Q2]		.14	.007	
...as a partner in number work [Q9]	.71	.31	.000	.000
...as a partner in reading and writing work with computer [Q8]		.31	.000	
...as best in using the computer [Q6]		.16	.001	
...as best in writing and spelling [Q2]		.12	.028	
...as best leader [Q5]		.10	.046	

Remark: The data are collected from 229 pupils. 'Stepwise' selection method is used.

Keys: "Q" refers to question item of the sociometric questionnaire.

The last question to be addressed in this section is "What are the similarities and differences between the predictors of popularity as partners in numeracy and literacy work with the use of computers?" The issue is addressed by making a comparison between the predictors reported in the last multiple regression models in Table T3-2-10 and in Table T3-2-9. To facilitate the comparison, the information is transferred into Table T3-2-11. It is obvious that pupils' choice-received as best in using the computer is a predictor for both types of work. There is also a link between the target variable of the first series of regression models and the target variable of the second series of regression models. Each of them is a predictor of another. Pupils' choice-received as a partner in email discussion and as a best friend are significant predictors of popularity as partners in literacy work with the use of computers because both of them bear the function of communication, which is positive towards literacy learning. The predictors seem to be subject-specific or literacy-specific, and they are not on the list of predictors of popularity as partners in numeracy work with the use of computers. Similarly, pupils' choice-received as a partner in number work also functions as a subject-specific predictor. It might means that pupils' subject knowledge is one of the key criteria for popularity as partners in numeracy work with the use of computers. In contrast, pupils' subject knowledge does not seem to be one of the key criteria for popularity as partners in literacy work with the use of computers. Lastly, the results might imply that language skills or/and leadership also have a role to play in numeracy work. However, they are the least important in making contributions to popularity as partners in numeracy work with the use of computers.

Table T3-2-11: A comparison between predictors of popularity as partners in numeracy and literacy work with the use of computers

Predictors of popularity as partners in numeracy work with the use of computers	Predictor(s) of popularity as partners in literacy work with the use of computers
...as a partner in number work [Q9]	
...as a partner in reading and writing work with a computer [Q8]	...as a partner in number work with a computer [Q10]
	...as a partner in e-mail discussion [Q11]
...as best in using the computer [Q6]	...as best in using the computer [Q6]
	...as best friend [Q4]
...as best in writing and spelling [Q2]	
...as best leader [Q5]	

Summary of Chapter 3

- With reference to the literature review, upper primary pupils are likely to benefit from the use of computers as a mindtool, with which pupils construct their own knowledge.
- The pupils with high self-rated competence in using computers were good at processing visual and spatial information, perhaps because computer supported learning environments are often multi-sensory or multimedia in nature.
- Proper use of well-designed computer software application can increase pupils' learning motivation. Surface learning motivation (i.e. learning by rote or reproduction) was positively related to appreciation of software interactivity and to pupil attitude towards computers.
- In all pedagogical and instructional arrangements supported by the use of computers, teachers and educators need to consider pupils' competence in using the computers.
- The selected upper primary pupils' usage of concrete experience learning orientation was the lowest among the four learning orientations (i.e. concrete experience, reflective observation, abstract conceptualisation and active experimentation). Multimedia features of the computer could give support to this learning orientation by providing multi-sensory information through demonstrations and presentations.
- The effect of self-rated competence in using computers toward learning interacts with the effects of academic self-concept, surface learning motivation and concentration in learning, respectively.

- The pupils spent an average of 1.42 hours on the computer at school per week while they spent about 2.42 hours on the computer(s) outside the school. About half of the pupils used computers both for games and for learning purposes. The results apply to boys and girls.
- The effect of subject preference interacts with the effect of using computers for subject learning and teaching, however, consideration had to be given to gender differences.
- The pupils consistently think that they learn best when they are working in pairs with the use of computers in English lessons and maths lessons.
- More pupils felt that they were happier when working in a uni-gender pair than in a mixed-gender pair, and more pupils thought that they learned better in a uni-gender pair than in a mixed-gender pair. The results suggested that pupils were more willing to work in a mixed-gender group when they were aiming at better learning outcomes than when they were aiming at enjoyment during the group learning process, and vice versa.
- Some potential factors affecting pupils' popularity as partners in computer-supported/assisted learning tasks were explored. There were similarities and differences between the predictors of popularity as partners in numeracy and literacy work with the use of computers.
- The results for the major research hypotheses or major study focuses in this chapter are summarised in the table below:

Keys/Remark for the table below:
"Sig." refers to statistically significant, "**" refers to a significant finding at $p < 0.01$ level, "*" refers to a significant finding at $p < 0.05$ level, "x" refers to a non-significant finding with $p > 0.10$, "-*" refers to a significant finding at $p < 0.05$ level that disagree with the hypothesis, "-**" refers to a significant finding at $p < 0.01$ level that disagree with the hypothesis and "~" refers to uncertain. "Des." refers to results of descriptive statistics. "Corr." refers to the results of correlation test(s), "T-test" refers to the results of paired t-test(s) and "MR" refers to multiple regression.

Section	Hypothesis or focus of study (i.e. It was expected that...)	Results [Further reference e.g. table number]
3-1-4	It examines the internal consistency of 18 measurement scales. A scale with alpha statistic > or = 0.7 is reasonably good.	10 of the scales have alpha statistics of > or = 0.6 and 5 of them are > 0.7. The maximum is 0.79 and the minimum is 0.43. [Table T3-1-1]
3-1-5-1	It is assumed that each of the following variables will have a positive relationship with each of the learning outcome measures *mentioned in section 3-1-4 above* and section 2-3-4 in Chapter 2. These include:	[Table T3-1-3] Corr. with 12 outcome measures:
	• competence in using computers (self-rated),	** * ** * x x ** x ** ** x x
	• attitude towards using computers,	x x x x x x x x x x x x
	• software interactivity (value on),	x x x x x x x x x x x x
	• concrete experience orientation of learning,	* x x x x x ** x * ** x **
	• reflective observation orientation of learning,	x x x x x x x x x x x x
	• abstract conceptualisation orientation of learning,	x x x x x x x x x * x x
	• active experimentation orientation of learning,	x x x x x x x x x x x x
	• teacher-pupil relations (perception of),	x x x -* x -* x x x x x **
	• deep learning motivation,	x x x x x x x x x ** x **
	• achievement motivation,	x x x x x x x x x x x **
	• concentration (in learning),	** ** ** x x x ** ** ** ** x **
	• academic self-concept (in general),	** ** ** x x x ** ** ** ** x **
	• self-concept of maths ability,	** x ** x x x ** ** ** ** x **
	• self-concept of language ability,	** ** ** x x x ** ** ** * * *
	• social self-concept,	x * ** x x x * ** ** ** x x
	• self-concept in school and learning and	x x x x x x x * * x x x
	• time management.	** ** ** * x * ** ** ** x x x
	It is expected that the surface learning motivation will have a negative relationship with each of the learning outcome measures mentioned above.	* * * x ** ** x x x x x x
3-1-5-1	It is assumed that there are positive relationships between each of the computer-specific variables and each of the following personal characteristics:	[Table T3-1-5] Corr. with 3 computer-specific variables:
	• concrete experience orientation of learning,	** ** **
	• reflective observation orientation of learning,	** ** **
	• abstract conceptualisation orientation of learning,	** * x
	• active experimentation orientation of learning,	** x **
	• teacher-pupil relations (perception of),	x * x
	• surface learning motivation,	x ** *
	• deep learning motivation,	** ** **
	• achievement motivation,	** ** **
	• concentration (in learning),	** * x
	• academic self-concept (in general),	** ** x
	• self-concept of maths ability,	** * x
	• self-concept of language ability,	** * x
	• self-concept in school and learning,	** * x
	• social self-concept, and	x x x
	• time management.	x x x

3-1-5-2 Part 1	The focus is on the interaction effect between the computer-specific variable and another learning related variable. It is expected that: • each type of learning outcome is affected by self-rated competence in using computers; • each type of learning outcome is affected by surface learning motivation; and • the two effects above interact with each other, in relation to each type of learning outcome.	[Table T3-1-7] 2 out of 7 two-way ANOVA tests have sig. interaction effect: ** ** * * * *
3-1-5-2 Part 2	The focus is on the interaction effect between the computer-specific variable and another learning related variable. It is expected that: • each type of learning outcome is affected by self-rated competence in using computers; • each type of learning outcome is affected by academic self-concept (general); and • the two effects above interact with each other, in relation to each type of learning outcome.	[Table T3-1-10] 2 out of 7 two-way ANOVA tests have sig. interaction effect: * x ** ** * *
3-1-5-2 Part 3	The focus is on the interaction effect between the computer-specific variable and another learning related variable. It is expected that: • each type of learning outcome is affected by self-rated competence in using computers; • each type of learning outcome is affected by concentration (in learning); and • the two effects above interact with each other, in relation to each type of learning outcomes.	[Table T3-1-13] 1 out of 7 two-way ANOVA tests have sig. interaction effect: * x *
3-2-1	It was expected that: 1. pupils in this study (Year 4 to 6) would spend longer time on the computer outside school than on the computer at school; 2. there would be a gender difference between the amount of time spent on the computer at school, but there would be a gender difference between the amount of time spent on the computer outside school; and 3. the two measures of amount of time on the computer (i.e. mentioned in hypothesis 1 above) would be related to measures of learning outcome.	T-test: * x x Corr with 9 outcome measures: X
3-2-2	It was expected that: 1. there would be a link and a difference between pupils' attitude toward different subjects (i.e. English and maths) of the primary curriculum; 2. there would be a link and a difference between their attitude toward different subjects (i.e. English and maths) when the computer was used to support the subject learning; 3. the effect of subject preference would interact with the effect of using computers for subject learning; 4. there would be a gender difference in relation to the hypothesis 3 above; and 5. there would be a link between learning outcome and the relative preference towards learning with computers as an opposition to learning without computers.	Corr: X T-test: ** Corr: ** T-test: X * [Table T3-2-2] X (or ~X) needs attention to gender issue Towards learning maths with computers and 3 out of 10 outcome measures: **, *, *. Towards learning reading with computers and 10 measures: X

<table>
<tr><td>3-2-3-1</td><td>When children are working in a group with the computer, what is the optimum group size?</td><td>Des.: In pairs [Table T3-2-6]
(first choice 55% and 49% for English and maths activities with computers, respectively)</td></tr>
<tr><td>3-2-3-2</td><td>It was expected that, in an English or maths lesson with the use of computers for paired learning:
• pupils would be happier when working in a uni-gender pair than in a mixed-gender pair; and
• pupils would thought that they learn better in a uni-gender pair than in a mixed-gender pair.
It was also expected that:
• pupils would be more willing to work in a mixed-gender pair when their judgements about learning are based on learning effectiveness than when their judgements about learning are based on enjoyment of the learning process, and
• there would be a gender difference and a difference in subject preference in the above hypothesis.</td><td>[Table T3-2-7]
Desc.:
Support (apply to different subjects and gender groups)
Support (apply to different subjects and gender groups)
[Table T3-2-8]
T-test:
Support
(Boys: English**, Maths**;
Girls: English*, Maths**)
X, X</td></tr>
<tr><td>3-2-3-3</td><td>It was expected that:
• there would be a relationship between a pupil's popularity as partners in a maths-related learning task with the computer and his/her learning outcomes in maths;
• there would be a relationship between a pupil's popularity as partners in a language-related learning task with the computer and his/her learning outcomes in reading; and
• there would be a relationship between a pupil's popularity as partners in a subject-specific learning task with the computer and his/her popularity as partners in any other aspects of learning.</td><td>Corr.:
attainment **, gain *
Corr.:
attainment **, gain: X
MR:
the results are presented in [T3-2-9] and [T3-2-10]</td></tr>
</table>

Chapter 4

Pedagogical and instructional factors affecting the effectiveness of subject teaching and learning supported by ICT

The main purposes of this chapter are to:

1. introduce the pedagogical and instructional variables concerning the use of ICT to support effective teaching and learning which are examined in this chapter, and provide a literature review (section 4-1, section 4-2),
2. provide an updated picture of and information about recent trend/movement in pedagogical and instructional practice regarding the use of computers in primary classrooms in U.K. (section 4-4), and
3. predict each type of learning outcome measure addressed in the study by a group of variables that seem to be related to the use of ICT and give some possible explanations (section 4-5).

- A list of the sections in Chapter 4 –

(4-5-1-2) Pedagogical variables affecting academic learning gains

(4-5-1-2a) A multiple regression model predicting maths learning gains

(4-5-1-2b) A multiple regression model predicting reading learning gains

(4-5-1-2c) A multiple regression model predicting academic learning gains (the average of maths and reading)

(4-5-1-3) Pedagogical variables affecting performance in cognitive tasks and pupils' context score

(4-5-1-3a) A multiple regression model predicting non-verbal ability (in problems of position tasks)

(4-5-1-3b) A multiple regression model predicting verbal ability (in picture vocabulary tasks)

(4-5-1-3c) A multiple regression model predicting context scores

(4-5-1-4) Pedagogical variables affecting pupils' attitudes towards academic tasks and towards themselves and the school

(4-5-1-4a) A multiple regression model predicting attitude towards maths tasks

(4-5-1-4b) A multiple regression model predicting attitude towards reading tasks

(4-5-1-4c) A multiple regression model predicting attitude towards themselves and the school

(4-5-2) Inter-relationships between pedagogical factors

(4-5-2-1) Inter-relationships between pedagogical factors directly affecting outcomes and some other factors affecting the pedagogy concerning the use of ICT

(4-5-2-2) Clarification of causal relationships

(4-5-3) Applying the proposed model to predict learning attainments

(4-5-3-1) Triangulation/re-examination of the proposed model

(4-5-3-2) Applying the proposed model to predict learning attainment

(4-5-3-3) An alternative model to predict learning attainment and learning gains

- End of the list –

Introduction

The present chapter will begin with a review of literature and a discussion about some pedagogical and instructional variables concerning the use of ICT. It is hoped that they will provide a background for formulating a research design to predict learning outcomes using some variables presented in the model.

Then, we shall look at the meaning and the formulation of outcome variables and pedagogical variables. This will be followed by some descriptive and correlation statistics for the respective variables. A set of statistical models is formulated to predict each type of learning outcome measure addressed in the study, with a group of variables that seem to be related to the use of ICT. Taking account of the findings and discussion of previous models, another set of refined models is proposed. It is hoped that the information will provide an updated picture of pedagogical and instructional practice concerning the use of ICT to support effective curricular teaching and learning in the primary classroom. Several research questions will be presented at the beginning of some sections of the chapter, to serve as signposts for the presentation of the research work done.

(4-1) Value-added data as outcome variables

In Chapter 2, we have reviewed the basis of using pupils' attainment and progress as indicators of educational effectiveness. To move forward, this section will introduce four major kinds of outcome variable to be used for the exploration of the effectiveness of a group of pedagogical and instructional variables concerning the use of information and communications technology in primary classrooms. Information on these issues is based on data collected during the academic year 1996/97, 1997/98 and 1998/99. The year groups of the pupils involved ranged from reception up to year 6. The majority of the pupils involved were in reception year, year 2 and year 4 because they were the years originally selected in Performance Indicators in Primary Schools project (PIPS).

The attainment indicators are based on pupils' results in the PIPS tests expressed in standardised scores and the progress indicators are based on pupils' concurrent value-added information. For the specific purposes of this thesis, some other variables are formulated or reconstructed on the basis of the data provided by the PIPS project team in Durham. These variables are presented in italics in the tables below. A list of the outcome variables can be found in the four sub-sections below. There are also descriptions and explanations of the meaning of the variables.

Generally speaking, a variable beginning with an "s" refers to data collected in the academic year 1996/97, a "t" refers to data collected in 1997/98 and a "u" refers to data collected in 1998/99. A variable ending in a "ma" refers to maths outcome, a "re" refers to reading outcome, an "aa" refers to the averaged maths & reading outcome, a "pv" refers to picture vocabulary outcome and a "pp" refers to outcome in problems of position tasks. The middle part of a variable represented by an "o" refers to an attainment outcome, while an "r" refers to value-added outcome.

When data is not available for the specific year group, a cross will be put in the respective cell. The cohorts of PIPS include pupils in reception year, year 2, year 4 and year 6. For this thesis, data of pupil outcomes was collected from a group of teachers for three consecutive years. Due to the sampling decision of the TTAICT project, the 1996/97 database includes data from reception year, year 2 and year 4. Year 6 data is also included in the 1997/98 database in order to reduce the loss of teachers due to the mobility factor. The problem of attrition became a problem in the 1998/99 database. The numbers of teachers available in years 2, 4 and 6 were statistically too small for them to be treated as independent samples. Reception year data in 1998/99 is the only exception as it has a reasonable sample size for drawing statistical inference.

(4-1-1) Outcome variables based on T-scores of academic tests

Table T4-A1: Standardised measures of academic attainment

		1996/97	**Rec**	**Y2**	**Y4**	**1997/98**	**Rec**	**Y2**	**Y4**	**Y6**	**1998/99**	**Rec**
A1-1	Maths attainment	s_o_zma	✓	✓	✓	t_o_zma	✓	✓	✓	✓	u_o_zma	✓
A1-2	Reading attainment	s_o_zre	✓	✓	✓	t_o_zre	✓	✓	✓	✓	u_o_zre	✓
A1-3	Averaged attainment	***s_o_zaa***	✓	✓	✓	***t_o_zaa***	✓	✓	✓	✓	***u_o_zaa***	✓

Keys: "✓" means data available and "x" means data not available.

Variables in row A1-1 are the average maths T-scores of the class or the teaching group in PIPS tests and variables in row A1-2 are the average reading T-scores of the class or the teaching group in PIPS tests. Variables in row A1-3 are the average of the respective variables in row A1-1 and A1-2.

(4-1-2) Outcome variables based on T-scores of cognitive ability tests

Table T4-A2: Standardised measures of cognitive ability and background

		1996/97	Rec	Y2	Y4	1997/98	Rec	Y2	Y4	Y6	1998/99	Rec
A2-1	Problems of position score	s_o_zpp	x	✓	✓	t_o_zpp	x	✓	✓	✓	u_o_zpp	x
A2-2	Picture vocab	s_o_zpv	x	✓	✓	t_o_zpv	x	✓	✓	✓	u_o_zpv	x
A2-3	Context score	s_o_zwe	x	✓	x	t _o_zwe	x	✓	✓	✓	u_o_zwe	x
A2-4	Home background	*s_o_zbk*	x	✓	x	*t_o_zbk*	✓	✓	✓	✓	*u_o_zbk*	x

Keys: "✓" means data available and "x" means data not available.

Variables in row A2-1 are the average problems of position task T-scores of the class or teaching group in PIPS tests and variables in row A2-2 are the average picture vocabulary task T-scores of the class or the teaching group in PIPS tests. Variables in row A2-3 are the average context scores of the class or teaching group and variables in row A2-4 are the average home background scores of the class or teaching group.

(4-1-3) Outcome variables based on current value-added data in PIPS

Table T4-A3: Standardised measures of academic learning gains

		1996/97	Rec	2	4	1997/98	Rec	2	4	6	1998/99	Rec
A3-1	Maths gains	*s_r_voma*	✓	✓	✓	*t_r_voma*	✓	✓	✓	✓	*u_r_voma*	✓
A3-2	Reading gains	*s_r_vore*	✓	✓	✓	*t_r_vore*	✓	✓	✓	✓	*u_r_vore*	✓
A3-3	Averaged gains	*s_r_voaa*	✓	✓	✓	*t_r_voaa*	x	x	x	x	*u_r_voaa*	✓

Keys: "✓" means data available and "x" means data not available.

To calculate the current value-added data in PIPS, a context score is often used to predict pupils' maths scores or reading scores. Variables in row A3-1 are the average standardised maths gains of the class or the teaching group in PIPS tests and variables in row A3-2 are the average standardised reading gains of the class or the teaching group in PIPS tests. Variables in row A3-3 are the standardised average of the respective variables in row A3-1 and A3-2.

(4-1-4) Outcome variables based on various attitude measures

Table T4-A4: Standardised measures of attitudes

		1996/97	Rec	2	4	1997/98	Rec	2	4	6	1998/99	Rec
A4-1	Attitude towards maths	*s_zat_ma*	x	✓	✓	*t_zat_ma*	x	✓	✓	✓	*u_zat_ma*	x
A4-2	Attitude towards reading	*s_zat_re*	x	✓	✓	*t_zat_re*	x	✓	✓	✓	*u_zat_re*	x
A4-3	Attitude towards school	*s_zat_sh*	x	✓	✓	*t_zat_sh*	x	✓	✓	✓	*u_zat_sh*	x

Keys: "✓" means data available and "x" means data not available.

The three sets of variables in this section are formulated by three sets of affective measures. Variables in row A4-1 are the measures of pupils' attitudes towards maths in PIPS tests and variables in row A4-2 are measures of pupils' attitudes towards reading in PIPS tests. Variables in row A4-3 are measures of pupils' attitudes towards the school and towards themselves in PIPS tests. The values of these variables are expressed in T-scores, which is a standardised measure with scores falling between 0 and 100 and the mean score is 50. For year 6 pupils in PIPS, there are also measures about pupils' attitudes towards science, but they are not used in this study.

(4-2) Pedagogical and instructional variables and effectiveness of using ICT to support teaching and learning

This section will introduce some pedagogical and instructional variables concerning the effectiveness of the use of ICT to support teaching and learning to be addressed in this chapter and chapter 5. The variables are based on three major components of the "model of effective curricular teaching and learning supported by computers or other types of ICT" introduced in Chapter 2. These include:

- teacher behaviour
- teacher's practical knowledge and skills (offered/perceived)
- teacher characteristics

In this section and section 4-4, each of them has four sub-sections "A", "B", "C" and "D". The first component refers to section B and the last component refers to section D. The second component refers to section A and C.

(4-2-A) Teaching tasks before the learning process

Often the teaching process may start before the learning process occurs. Planning and preparation are typical activities that teachers often do before introducing the learning content to their pupils. During the process, teachers have to offer their knowledge and skills in a practical way. The sub-sections below are some of the areas that teachers need to take into consideration.

(4-2-A1) Knowing pupil characteristics and their ICT needs

The paragraphs below will provide discussions about three aspects of pupil characteristics. The major reason for the selection of these variables for this study lies in their potential links with the effective use of ICT. The paragraphs below will discuss their potential relationships with pupils' ICT needs and clarify their links with other ICT-related factors.

Age/year group

When considering the major difference between the use of ICT by pupils in lower and upper levels of primary education, three aspects of possible difference were identified in the literature review. Firstly, it is reasonable to expect that pupils in upper primary have more experience in using ICT than pupils in lower primary. If school is the only place where children gain access to ICT, children at upper primary will have more accumulated exposure and experience with ICT. So, if we discount opportunities at home, children in early years of primary education will need to develop skills in using ICT in order to be able to interact with it. The ability to use the keyboard and the mouse are regarded as two basic areas of ICT skills (Ager, 1998, chapter 9, page 126). It is likely that the performance of a typical young child in these two areas is not as good as that of an older child.

Table T4-B1-1a: Pupil experience of using computers during a typical week in 1995/96 and 1997/98

	% of pupils who used a computer during a typical week (95/96)	% of total lesson time per week in which computers were used by pupils (95/96)	% of total lesson time per week in which computers were used by pupils (97/98)
Reception	65	42	48
Year 1	62	43	47
Year 2	61	45	48
Year 3	54	41	45

Year 4	57	43	45
Year 5	56	44	46
Year 6	58	45	46
Overall Average	59	43	46 (including Yr 7/8)

Secondly, there are differences in the ways children approach computers and in the type of computer usage (Adams & Hamm, 1989, Chapter 8, page 165). Children in upper primary are likely to be in a later stage of cognitive, social and emotional development. Compared with children in lower primary, they will be more able to express themselves and have a longer attention span. They may also be able to use the computer or ICT as a tool for output, while children in lower primary might use it as a tool for receiving inputs. Multimedia presentations on the computers might be common for children at all years, but word processors are more likely to be used by children at upper primary than by those at lower primary. As their attention span is relatively short, children of lower primary may have a shorter duration of time on the computer than children of upper primary. Studies of pre-school children's computer use and social pattern show that children at that age prefer working in groups of two or three, rather than working independently on the computer (Adams & Hamm, 1989, page 165). These results lead to the inference that children in lower primary are more likely to have a turn on the computer than children in upper primary have. This is weakly supported by the government's statistical figures obtained from the survey of ICT in schools in the academic year 1995/96 and 1997/98, as presented in Table T4-B1-1a above.

The table shows that the percentage of pupils who used a computer during a typical week in 1995/96 was higher among pupils in reception to year 2 than among pupils in year 3 to 6. The percentage of total lesson time per week in which computers were used by the two contrasting groups of pupils was roughly the same. The hypothesis that pupils in the early years of primary have a shorter, but more frequent use of computers than pupils in upper primary is supported by the data from the 1995/96 survey. Unfortunately, the official released information did not allow us to check the difference in the percentage of pupils who used a computer during a typical week between lower and upper primary pupils identified from the 1995/96 survey against the statistics from survey 1997/98. Comparing data of the 1995/96 and 1997/98 surveys, there was an increase in the overall percentage of the total lesson time per week in which computers were used for pupil learning.

Thirdly, there are concerns about the use of computers in early childhood education. For instance, the posture when a child is working on the computer for long hours may have negative impact on their physical development. Computer activities that are dominated by practice drills may limit children in the use of creativity. Clements & Nastasi (1993) expressed the concerns on their use to fulfil children's need for symbolic play and their social and emotional development. In spite of the limitations of technology, it is doubtful whether computers can provide children with the right extent of their needs. A recent report published by Alliance for Childhood in US (Cordes & Miller, 1999) has summarized the hazards of computers in childhood in the following aspects:

- hazards to children's physical health,
- risks to emotional and social development,
- risks to creativity and intellectual development, and

- risks to moral development.

On the other hand, there are potential benefits for children in various aspects of learning, including various subject teaching (e.g. TTA, 1998), the development of basic skills, high-order thinking and creativity. Aspects of successful and effective use of ICT are further demonstrated in the TTAICT project (Moseley et. al., 1999). The results seemed to be complex, but they are not contradictory. Instead, they are telling us that the impact of ICT is rather neutral. They are determined by how it is used. There is little evidence that computers should not be introduced to younger children (Clements & Nastasi, 1993). One of the crucial factors for a successful or effective use of computers is the appropriateness of the teaching and learning context when computers are used. Appropriate use bears the characteristic of fostering the transfer of skills learnt with the support provided by computers to become a personal ownership of the skills without the support provided by computers, which is applicable to real life situations and the authentic living environment (e.g. McFarlane, 1997).

Number of pupils

Generally speaking, several researchers have found that class size is negatively related to learning outcomes, but there isn't enough evidence to conclude about the effect of class size. For example, Glass & Smith's (1978) meta-analytic study made a comparison of the performance between a class of 30 pupils and a class of 15. The latter was found to be almost 0.5 standard deviation better than the former. The performance of a class of 5 pupils was about 1 standard deviation better than that of a class of 30. The results of the study is not surprising and can be explained by the difference in the amount of resources and attention that pupils in different class size receive, as suggested by some other literature about class size. Slavin (1989) reanalysed Glass & Smith's data and found the effects of class size were very small. The effect size of reducing a class from 30 to 15 students was only one tenth of a standard deviation of student performance. The range of the effects of class size was also found to be discontinuous. Having said that, the results of recent researches have failed to provide a clear answer. For example, a recent study of education achievement of Belgium found that class size was negatively related to achievement in the Flemish speaking part of the country, but it was positively related to achievement in the French speaking part of the country (Reynold & Farrell, 1996).

Johnson and Ross (1989) reported the use of computers for socio-economically disadvantaged and academically "at-risk" students at fifth grade and sixth grade in Memphis on a periodic basis over an 8-week period in the Spring of 1989. Repeated observations found that all the three teachers involved made effective improvement in learning. These included a mathematics teacher, an English teacher, and a reading teacher. The authors concluded that the math and reading teachers seemed to use the computer effectively for reducing the teacher-student ratio. The computer and applicable software were used as a teaching aid to provide learning experiences for the rest of the class, while retaining the instructional benefits to be experienced when instructing smaller groups. Therefore, the educational benefit may not directly result from the use of computers, but the indirect benefit for the reduction in class size and the facilitation of independent tutoring.

In the present literature review, no other literature was found directly describing the relationships between class size and the effectiveness of using computers in primary education. The closest literature found in this review was research done by Gunter & Gunter (1994) who compared the computer attitude scales (CAS) measured before and after a computer literacy course for higher education students. They reported that, among the 317 students in the study, students in smaller classes perceived computers to be more useful after the course than students in larger classes. They concluded that there was a significant difference in the attitudes towards the usefulness of computers between students in different class sizes at higher education level.

It would be sensible to expect that class size has a role to play in the use of computers in primary classrooms, however, no clear pattern of relationship has been found. Given that the number of computers available to the class is unchanged, the higher the number of pupils in class, the less often will a pupil have a turn on the computer or, alternatively, the shorter the duration of computer time per pupil. Again, the amount of attention that teachers can pay to each pupil in a small class is higher than in a large class. Having said that, large classes often have more resources and more flexibility in allocating resources - including ICT resources, than small classes. The discrepancy between resource allocation and resource management flexibility between different class sizes will increase the complexity of the issue about class size and effectiveness of using ICT.

Number of pupils on the special educational needs register at stage 3-5

There are several ways that the number of pupils with special educational needs relates to the effective use of ICT. Firstly, according to the stage of need, children with special educational needs may require special instruction and provision of ICT equipment. The special educational co-ordinator (SENCO) and the IT co-ordinator in the school have the responsibility for providing the appropriate equipment and resources for their needs. Children at the code of practice stage 1 will normally have "shared provision". This means the child will share the same activity and learning outcome with other children in class. Children at stage 2 may require a more specific programme of activities. Although their learning outcomes might well be similar to other children in class, the activities may need a finer breakdown into sub-stages or steps. For children at stage 3 of the register, it is likely that external advice is needed. Sometimes extra ICT equipment is needed. It is loaned to the child either from within the school resources or from external agencies. Provision of the latter type is sometimes described as "designated provision". Children at stage 4 and 5 of the register are those with a statutory assessment. Specific ICT provision is often needed. If the school does not have the right equipment available for the child, the Local Education Authority may need to fund the equipment. Therefore, the provision of equipment is often described as "individual" or "specific" provision.

There are differences in the use of ICT between children with and without special educational needs. Generally speaking, children with special educational needs may require longer computer operation time. For instance, children with moderate or severe learning difficulties might need ICT tasks that are different from those of their peers. Sometimes, the tasks are designed for younger children or specially designed for special educational purposes. Sometimes these computer applications may only require simple operation skills. Children with physical disabilities may have difficulty in accessing the computer. Special ICT equipment such as special keyboards, keyguards, pointing devices, switches or other special inputting device may be needed. Once they have successful access to the computer, their computer operation and usage may be comparable to that of other children in the class. Besides this, there are children with other types of special educational need. They may require different degrees of help with their use of ICT.

In spite of the discussions above about the difficulties that children with special educational needs have to face, it is likely that a class with a large number of children with special educational needs will have lower learning attainment and/or rate of progress than an ordinary primary class in the country. In the section about instructional design below, we shall talk about two more things that teachers can do to help children with special educational needs to use ICT effectively.

Measures of pupil characteristics in this study

Three measures of pupil characteristics were collected through the administration of a teacher questionnaire in the academic year 1997/98 and 1998/99. These items are listed as Table T4-B1-1b below:

Table T4-B1-1b: Variables concerning pupil characteristics

Variable	*Samples (N)*	*Items*
aag_97	*247*	*Which year group are you teaching this year?*
aag_98	*119*	*as above*
aanp97	*246*	*How many pupils are there in your class?*
aanp98	*83*	*as above*
asnu97	*250*	*How many of your class are on the Special Needs Register at Stages 3-5?*
asnu98	*72*	*as above*

The variable concerning teaching year group would be useful to the age or year group of the pupils taught by the respective teacher. Given that the surveys in both years were repetitive, if the sampling and data collection were reliable, it was expected that:

- the data of each pair of variables concerning teaching age/year group would be positively correlated with each other, and
- the difference between each pair of variables would not be statistically significant.

The collected data also would then be used to classify the respondents into three levels of primary education, as in Table T4-B1-1c.

Table T4-B1-1c: The classification of levels of primary education

Level in primary education	**Year group range**
Level 1	Below year 2
Level 2	Between year 2 and below year 4
Level 3	Year 4 and above

Furthermore, if the sampling and data collection were reliable, it was expected that the difference in the number of pupils in each level of primary education would not be statistically significant. The number of pupils in class would negatively affect the provision of equipment and pupils' opportunity to access the computer. A large class-size may hinder teachers' intention to use ICT because that would increase their workload.

In primary education, it was expected that there would be fewer SEN children registered at stage 4-5 in lower primary levels than in upper primary levels. The major reason for that is the duration of time needed to identify and to confirm a child with SEN. More formally identified SEN children in class might be associated with the lack of equipment or the number of hardware or software add-ons, as discussed above. As some of the equipment was assigned to SEN children, it would reduce the amount of equipment available to other children in the class. If the number of SEN children in class is high, it may bring down pupils' opportunity to access the computer. So, when planning for their lessons, teachers with many SEN children in their class may tend to avoid the use of ICT.

In relation to the discussion about effectiveness of education .and the use of computers, it was expected that the pupil learning outcomes would be:

- negatively related to the number of pupils in class, and
- negatively related to the number of SEN in class.

(4-2-A2) Provision of ICT equipment and resource allocation

At the planning stage of teaching supported by ICT, teachers have to provide pupils with the ICT equipment they need. Practical considerations and decisions are often involved. Resource selection and allocation are examples of these considerations.

Provision of ICT equipment

Roblyer et. al. (1997) stressed that one of the primary obstacles for integrating technology into American classrooms was that teachers would often "shy away from using technology in their teaching" as they felt they did not have "reliable access to enough equipment". McKinsey and Company (1997) surveyed the ICT resources in UK schools. It was found that there were on average 10 computers in each primary school by 1997. About forty percent of the UK primary classrooms only had one computer available for use by 20 or more pupils. These figures showed improvement in computer resources, when compared to statistics of a national survey mentioned in the ImpacT project. It was reported that the national average of the number of computers per primary school in 1991 was 4.3 and the average number of pupils per computer in primary schools was 40 (Watson, 1993).

In terms of availability of basic hardware, the UK could be described as "ahead of most other countries". However, the functionality of equipment was greatly limited by the large percentage of aged equipment. By 1993-94, about 40 percent of the computers in schools were over five years old. The number of computers available in primary and secondary schools was also less than the number of computers available at home. In 1993-4, there were already four times as many computers per child at home compared with the number of computers per child in primary schools. By 1997, the independent report done by McKinsey and Company (1997) stated that the lack of reliable and updated equipment was one of the two major limitations in the use of ICT in the UK. And the computer equipment provision also varies between classrooms and between schools. The type of equipment provision model the school has adopted affects the number of equipment and add-ons actually available for the use by teachers and pupils.

Table T4-B1-2a: Internet facilities available for primary schools from 1997/1998 to 1999/2000

	97/98	98/99	99/00	97/98 C.I. upper lim.	97/98 C.I. lower lim.
Connected to the Internet					
% of primary schools connected to the internet	**17**	**62**	**86**	19	15
Number of internet access points (average per school)	**2**	**4**	**8**	-	-
% of schools who had their own web sites		**21**	**34**		
E mail Access					
Teachers (% with personal e-mail address)	**1.7**	**15**	**37**	3	1
Pupils (% with personal e-mail address)	**0.2**	**4**	**9**	-	-

The computer peripherals, hardware or software add-ons are also determinants of the functionality of the computer. These computer peripherals or add-ons include hard-disk drive, CD-ROM, printer, ILS software and the connection to internet. There was research evidence supporting the usefulness of certain computer peripherals or add-ons. For examples, Barron et. al. (1992) reported their success in combining letter-sound knowledge and feedback by computer printouts which facilitated non-readers' awareness of phonemes. Sizmur et. al. (1998) investigated the effects of three integrated learning systems on pupils at year 5, 6 and 8. The results of Pawling's (1999) qualitative research suggested that CD-ROM could enhance vocabulary acquisition, pronunciation and independent learning and had benefited the language teaching and learning processes. Hartley (1998) pointed out that many readers identified more punctuation errors, more misspellings, and more lack of balance between short and long sentences that they somehow missed on screen versions of their text, when compared with working on the printout. He extended his discussion with Cowan about the need of experienced writers to edit their text in the form of printouts or in electronic format. BECTa (1998b) suggested the educational value of National Grid for Learning (NGfL) resources, which was accessible through internet since January 1998. The government's statistics showed that the number of schools connected to the internet has increased sharply during the last three years before the year 2000. Unfortunately, the major usage was restricted to electronic mailing purposes and the actual usage of the facility was not high. For example, only 1.7% of the teachers and 0.2% of the pupils had their own email address when the project began in the autumn term in 1997. Only 1% of the schools had the facility for video conferencing or bulletin boards purposes, respectively. The details of these figures are reported in the Table T4-B1-2a above.

Lewis and Costley (1997) evaluated and demonstrated the success of using the "Autoskill Academy of Reading", an integrated learning system (ILS) software, for secondary age pupils with learning difficulties in improving reading achievement. Sizmur et. al. (1998) evaluated three ILS and concluded that they were effective in improving pupils' motivation and behaviour, although there was a lack of evidence that this was transferred into learning gains. The result was fairly consistent with those mentioned in another independent ILS evaluation report by BECTa (1998a). In the report, Wood (1998b) stated the educational contributions made by ILS in terms of pupils attitudes towards school work, motivation, behaviour and self-esteem, but the extent of the learning gains were not consistent. He concluded that "the main issue is not if pupils learn but what and how they learn" and there was "a growing body of evidence which shows that the potential of ICT to help pupils' learning depends critically on how it is used by teachers and schools".

Therefore, perhaps the next pedagogical issue to consider is the functions that reliable computer equipment can perform. The requirement mentioned in Initial Teacher Training National Curriculum can be a reasonably good example to demonstrate a broader vision of applying the functions of IT in subject teaching and learning. This includes (TTA, 1998, page 4):

- how the speed and automatic functions of ICT can enable teachers to demonstrate, explore or explain aspects of trainee teachers' teaching, and pupils' learning, more effectively;
- how the capacity and range of ICT can enable teachers and pupils to gain access to historical, recent or immediate information;
- how the provisional nature of information stored, processed and presented using ICT allows work to be changed easily;
- how the interactive way in which information is stored, processed and presented can enable teachers and pupils to:

- explore prepared or constructed models and simulations, where relevant to the subject and phase;
- communicate with other people locally and over distances, easily and effectively;
- search for and compare information from different sources;
- present information in ways which are accessible in different forms for different audiences.

Unfortunately, a local survey showed that computer resources in the UK were not good enough to cope with the rapidly increasing educational needs. McKinsey and Company (1997) reported that a high proportion of the hardware was out-dated or far from being modernised to cope with the requirement of latest software. Watson (1993) specifically defined the lack of access to computers as one of the three principal factors that affected the use of IT in the classes in the ImpacT project report. We shall come back to the issue of equipment provision when we address issues concerning the quality of instructional design, and the challenge, barrier or obstacles of using ICT later in this thesis.

It would be reasonable to expect that functionality of ICT equipment would affect the quality of instruction provided or supported by computers, which is an issue to be addressed in the sub-section 4-2-B2 below. However, besides measures of provision of ICT equipment and the hardware and software add-ons, there is no further measure of the functionality of equipment, such as speed, automaticity, provisionality, interactivity,...and so on. It was believed that the actual performance of the computer would have been better measured by classroom observations, rather than through the use of questionnaire. In fact, data concerning the technical reliability of the hardware and software was collected during classroom observations in the TTAICT project. Unfortunately, the size of the data was too small for quantitative analysis to be used in this study.

Resource allocation

Hartoonian (1984) suggested that the trend of educational use of computers was moving beyond the emphases on the function of seeking information and was moving towards the emphases on the function of seeking knowledge and wisdom. To enable this dimension of evolution of usage of computers, he stressed that there "must be equal opportunity for computer usage relative to class, race, and sex". Inequality in the allocation of ICT resources and the opportunity to access the resources were identified across races, geographical locations, gender groups, social classes and organisations.

For instance, the results of a survey study of 240 secondary students in New Zealand (Nolan et. al., 1992) showed that pupils in different gender groups use computers in different ways, although no significant difference in computer access was found across ability, gender, and socio-economic status. In 1996, 6,227 grade 4 students' were involved in a large survey of the opportunity to access computers for maths work was carried out by the National Assessment of Educational Progress (NAEP) in United States. The results of the survey found that black students reported a higher frequency of school computer use than white students did. Students in the Southeast used computers more frequently than students in Midwest, while students in other regions were somewhere in the middle. Public school students also had a higher frequency of computer use than students in private school did. No difference was found across gender, economic status, or community status (Educational Testing Service, 1998). Research findings so far seemed to be inconsistent and controversial. The inconsistency was detected by Burmeister (1992), who stated that the amount of computer use and the computer skills/experience differ from grade to grade and classroom to classroom in elementary schools. The inconsistency in access opportunity is linked closely to the lack of a standard approach of allocating ICT resources across different educational settings. SOEID (1999) reported that there seemed to be "no single approach" which would be right for all schools and it would be important that "teachers and managers" were made aware of the need to consider the issues related to computer access in the context of their own school.

Due to the inconsistency of the effect of resource allocation strategies, further investigations will address the variation of equipment available to different age/year group as well as the variation between teachers/classes in the UK. Furthermore, section 4-2-B1 and section 4-4-B1 will address the issue concerning resource allocation with a measure of the computer usage intensity, which was defined as the opportunity for a typical pupil to have a turn on the computer. To sum up, the lack of provision of computer equipment limits or hinders the opportunity for pupils to use the computer and the effectiveness of its use.

Measures of available ICT resources in this study

Information about the ICT resources available to the class was collected by the teacher questionnaire carried out in the academic year 1997/98. There were three main focuses concerning the provision of equipment. These include the number of computers available to the class, the number of hardware and software add-ons, and the availability of other ICT equipment. These items are listed as follows:

Please put a number in the appropriate box below to show how many computers of each type you have for use by your class (there is no need to put in zeros - just leave blanks):

	BBC	*Acorn*	*PC/RM*	*Apple Mac*	*Portable e.g.laptop*	*Other*
I can use all the time						
I can use sometimes						
(How many other classes do you share them with)						

Please indicate how many computers:

[in %]	*BBC*	*Acorn*	*PC/RM*	*Apple Mac*	*Portable e.g. laptop*	*Other*
Are connected to a printer						
Have a CD Rom						
Have a hard disc drive						
Are connected to the internet						
Have ILS software installed						

Other ICT equipment

How many calculators are available to you?	
How many hand-held spell checkers are available to you?	
How many programmable floor toys e.g. (Roamers/Turtles) are available to you?	
How many concept keyboards are available to you?	
How many digital cameras are available to you?	
How many musical keyboards are available to you?	
How many children in your class sent a fax from school this term?	

The first focus was the number of computers available for use by the respondent's class. When a computer was available only through the sharing with other classes, it was counted as "0.5". Descriptive statistics showed that the minimum and maximum number of computers available were 0 and 20. The mean was 2.18 and the standard error of the mean was 0.14. According to the total number of the available items, the provision of computers was classified as 6 categories, from no provision to the richest provision. The data was transformed into a composite variable named as "com_cat", as presented in Table T4-B1-2b.

The second focus was the number of peripherals available for use. It was recorded as one available item for each computer peripheral, such as a CD-ROM, a hard disc, an internet connection point or the availability of an integrated learning system (ILS) software. The mean was 7.64 and the standard error of the mean was 0.68. The minimum and maximum were 0 and 76, respectively. According to the total number of available items, the provision of peripherals was classified as X categories. The data was transformed into a composite variable named as "peri_cat", as presented in Table T4-B1-2b.

Table T4-B1-2b: Composite measures of equipment provision

Variable	Composition of the scale
cncom	No. computers available (shared counting as 0.5)
cperi	Total score for hardware/software add-ons
cprov	2*com_cat + peri_cat + (1/7)*(calc_cat + spe_cat + tur_cat + con_cat + cam_cat + mus_cat + fax_cat)

The third focus was the provision of some other types of ICT equipment, excluding computers. The availability of a hardware device was counted as one available item. This included a calculator, a hand-held spell checker, a programmable toy (e.g. a Roamer/Turtle), a concept keyboard, a digital camera, a musical keyboard or a fax machine by a pupil at school. A composite variable "cprov" was formulated to indicate the overall provision of ICT equipment. The formula of the weighting, which describes the compositional structure of the variable, was reported in Table T4-B1-2b above. It is possible that the relative weighting of the equipment provision focuses could become a controversial issue. However, the decision to adopt the present compositional weighting system was made after various discussions between the TTAICT project team members and the PIPS project team members. It is therefore, assumed to be the best composition known to the two project teams at that time.

Two measures of internet access facility were collected through the administration of a teacher questionnaire in the academic year 1998/99. Here are the items:

How many internet access points are available in your school: (You may need help from IT co-ordinator) *for teachers' use* ________ *for pupils' use* _________

It was expected that more computers with better hardware and software add-ons would be needed for pupils in upper primary than in lower primary. More computers presentation time and better equipment would be needed for presentation of complicated topics. So, the general equipment provision in upper primary was expected to be better than in lower primary. Similarly, it was expected that more internet access points would be available for teachers and pupils in upper primary than in lower primary.

In relation to the effectiveness of education and the use of computers, it was expected that the pupil learning outcomes would be:

- positively related to the number of computers available,
- positively related to the number of hardware and software add-ons,
- positively related to the general provision of equipment, and
- positively related to the number of internet access points available for teachers and for pupils.

(4-2-A3) Instructional setting, planning and decision-making

The use of computers to support subject teaching and learning

Findings of many studies in 1970s and 1980s supported the use of computers in the teaching and learning of various subjects at secondary school, college and higher education levels. For example, Lang and Brackett (1985) found a significant improvement after using computers for remedial reading for 48 college students; Russell et. al. (1976) reported another study concerning the successful use of computers to support science education at College level; Henderson et. al. (1983) found the use of computer-video instruction effective in affecting the performance of underachieving high school students in maths. However, the use of computers in teaching and learning processes may not always have an impact on pupil learning, and when there is an impact, the impact may be positive or negative. The instructional environment in which computers are used often determines the nature of the impact.

Teachers' planning and decision-making concerning the use of computers is often determined by their pedagogy. This implies the need for researchers to search for the best instructional environment and an effective pedagogy in which computers are used to support teaching and learning. McCormick and Scrimshaw classify three different types (or levels) of usage of ICT in relation to their pedagogical implication:

"

- ICT as efficiency aid - ICT is employed to improve the efficiency of conventional teaching.
- ICT as extension device - ICT as a way of extending the reach of teaching and learning, but still within a largely conventional framework.
- ICT as transformatory device - ICT as a way of fundamentally transforming teachers' and learners' conceptions of the subject itself.

(adapted from McCormick and Scrimshaw, 2000, page 8)"

Unfortunately, early research concerning the use of ICT did not tell us much about "When to use ICT" and "When not to use ICT" for curricular teaching and learning in primary education. The most useful recommendation was found in the project report prepared by the Centre for Educational Research and Innovation (CERI, 1976) in France. In commenting on how to use computers in the teaching and learning of several secondary school subjects, the report suggested that computers should be used in teaching "only tasks that either it alone can fulfil, or that it can carry out markedly better than any other resource within economic limitations". With the criterion applied to the project, computers were found to be a successful tool:

(1) in teaching biology and physics;
(2) in mathematics, social sciences, business studies, and the humanities; and
(3) in materials design, guidelines for package documentation, dissemination of materials and information, and teacher education.

The criterion implies that the effectiveness of using computers is greatly determined by the planning and instructional decision making in which computers were used to support teaching and learning. Attention should be paid to the instructional environment as a whole, in which the contributions of ICT is an integral part of it. In other words, an effective pedagogy of using ICT for curricular teaching and learning should not only focus on maximising the potential of ICT on its own, but also on the integration of the use of ICT into the primary curriculum.

The use of computers to support integrated curriculum

Besides using computers to support subject teaching and learning, the content of the computer activity might appear as an integrated activity that is cross-disciplinary in nature. For example, Kurtz (1968) reported the success of a project in integrating the use of computers in various parts of the curriculum to enhance the teaching and learning of mathematics, the sciences, and other secondary school subjects. McKinnon et. al. (1997) reported the successful use of a computer program as an integration of mathematics, history, and language arts skills in the curriculum. Data were collected from 3 cohorts of students over 3 years. A total of 415 junior high school students in New Zealand were involved. Students who participated in the integrated studies program had more positive attitudes toward computer use than those who learnt under the traditional school program. They also reported more enjoyment of out-of-class activities. Students in the integrated studies program were significantly less alienated than their counterparts in the regular grade-9 programs, and their English, mathematics, and science achievements were also higher.

Davis and Shade (1994) stressed the benefits of using computers to support an integrated curriculum. They thought that computers could be used as natural tools for learning when they were applied to solve real problems. This was an example that they cited, "When a teacher chooses a topic for an integrated study project, the class will define relevant concepts related to that topic and choose activities to explore those concepts. Sometimes computers will be the most appropriate tool for exploring the concepts. As they work on their project, children can use computer programs to construct stories with pictures, labels, and voice recordings; gather information from

CD-ROM encyclopedias; compose and illustrate stories; and write letters to experts. Children can also use microworlds, or programs that help them discover concepts and cause-effect relationships, and serve as a bridge between hands-on experience and abstract learning." They concluded that "without proper integration of computers into the curriculum, the benefits of technology to foster children's learning cannot be fully achieved, regardless of the creative potential of any software used". The authors tried to make a comparison between Integrated Learning System (ILS) and true integration. They commented that activities in the ILS software that were available at that time were not closely related enough to illustrate the target topic. This hindered children's conceptual development. Instead, they pointed out "real knowledge" was truly "integrated" and they were "much more than a group of unrelated segments; each section supports a particular function, and all are related to one another". The interrelationships of the subjects had to be integrated in a natural way. To achieve the learning goal of a truly integrated topic, knowledge of various subjects (e.g. language, mathematics, science) would be required.

Approaches and effectiveness of integrating computers into the curriculum

So far, very little literature has presented concrete models or frameworks about how to integrate computers into the curriculum. The book that Roblyer et. al. (1997) wrote seems to be one of the few that is supported by teaching and learning theories. The authors have suggested two methods of integrating technology into the curriculum. The two methods are grounded in different approaches to teaching and learning practice and they are achieving different educational purposes. Here is a list of the purposes under each of these instructional methods, as suggested in the book:

1. On the basis of a direct instruction method, the integration of technology is to:

- remedy identified weaknesses,
- promote fluency or automaticity of pre-requisite skills,
- make learning efficient for highly motivated students,
- optimize scarce resources,
- remove logistical hurdles.

2. On the basis of a constructivist instructional method, the integration of technology is to:

- generate motivation to learn,
- foster creativity,
- facilitate self-analysis and meta-cognition,
- increase transfer of knowledge to problem solving, and
- foster group co-operation.

The former method tends to be a teacher-centered approach, while the latter method tends to be a learner-centred approach. The two approaches seem to be the typical extremes. In the planning for the integration of technology into the curriculum, the actual method that most teachers use will fall on the line between these two.

Mevarech (1997) attempted to outline the process that trainee elementary teachers experience in integrating computers into the curriculum by a U-curve model. He questioned the assumption that gaining experience was a linear development process. He further proposed that integrating computers into the curriculum was a "U-curve process that involved a negative side of decline in performance" and "followed a positive side of overcoming difficulties and reconstructing teachers' pedagogical content knowledge". He described the process in the four stages below:

- survival,
- exploration and bridging,
- adaptation, and
- conceptual change and invention.

In relation to the two methods that Roblyer et. al. (1997) suggested, it is possible that teachers that worked under different methods of integrating technology into the curriculum might have different experiences in their professional development. One might expect the U-curve model to have a stronger influence on teachers under a teacher-centred approach of integration than those under a learner-centred approach of integration. This would imply the need to look at the pedagogy concerning the use of ICT from the point of view of professional development of teachers.

Planning for instructions and adjustment of instructions: the use of integrated learning system (ILS) and computer-managed instruction (CMI)

Computers can be used in a subject-specific curriculum or used in an integrated curriculum. Both types of use require instructional decision making and instructional planning. The use of computers might be specified in the curriculum planning stage, in the teacher's weekly and/or daily lesson planning stages. Curriculum planning might happen well before the pupils' first use of ICT in their classroom. For example, pedagogical decisions concerning the curricular use of ICT could have been made before the start of an academic year or an academic term. Planning the use of ICT would enable it to be used more systematically and regularly, and lead to better learning outcomes. On the contrary, schools without a long-term plan for the use of ICT might use it less regularly and non-systematically. To make teaching and learning effective, teachers often need to make pedagogical decisions about when to use ICT and when not to use ICT, as mentioned above. Depending on the pupil characteristics, teachers may need to plan specific computer activities or to adapt the use of programs to suit pupils with special needs. Depending on the software program, teachers might need to prepare instructional material to support ICT activities or make adaptations to the use of computer programs so as to match with other non-ICT related activities.

Quality of software programs and complementary instructional arrangements

There are different kinds of software program and there are different ways of classifying them. In the literature review, two of the classifications were particularly impressive. The first classification is suggested by Kemmis et. al. (1977). On the basis of the usage of Computer Assisted Learning, software programs can be classified as instructional software, revelatory software, conjectural software, and emancipatory software. The second classification distinguishes "subject-specific" software programs from "generic software" programs (adapted from Loveless, 1995, chapter 1, page 17; Collins et. al. 1997, chapter 2, page 16 and Scrimshaw, P., 1997). The former type of software program contains specific subject content in the primary curriculum, while the latter type is not content-specific or content-free. For example, drill and practice software programs in maths belong to the former classification and word-processing packages belong to the latter.

The content of subject-specific software programs is relatively "closed" or "controlled" when compared with the content of generic software programs. This way of classifying software has close links with the way the software program is used. In other words, a software program may be classified as a subject-specific software program at one time and as a generic software program at another because the classification is also dependent on the nature of these activities. When an internet browser is used to read an electronic book, it is regarded as a subject-specific software program. When an internet browser is used to search for specific information required by the learner, it is regarded as a generic software program. The information available to the software program is relatively open, however, the content of the information is specified by the user.

Collins et. al. (1997) suggested the importance of looking at the context of multimedia from an interactionist perspective. They thought that the key question to ask of any software is "What do learners and teachers do with it?" From the proposed perspective, it is highly possible that unattractive software can promote successful classroom activities. For example, as a type of emancipatory software program, electronic spreadsheet or word processing software can be an effective learning tool for pupils to explore number patterns or for creative writing purposes. On the other hand, an emancipatory software program can be used for quite untaxing, mindless activities such as entering large sets of data on a word-processor or a spreadsheet.

Nevertheless, Mercer & Fisher (1992) point out that "although software is of course a defining influence on activities, our observations show that in practice the procedures and outcomes of any computer-based activity will emerge through the talk and joint activity of teacher and pupils". On this basis, teachers should not let the success or failure of a learning activity be determined by the quality of a software program. They are responsible for the effectiveness of all the activities in the lesson, not merely activities with the use of ICT or other non-ICT related activities.

Being a tool for the teaching and learning process, the use of computers does not guarantee the success of the teaching and learning activities. There are many factors that affect use and effectiveness. Cognitive psychology views learning as results of the interaction between motivational factors and environmental factors. The question about effectiveness of using ICT is addressing the relationships between the characteristics of individuals and the capability of ICT. With reference to the two examples above, the interactionist approach has suggested that the use of ICT should not be restricted by the quality of the software programs, but it is greatly determined by what learners and teachers do with technology. As pointed out by Collins et. al. (1997), the question about effectiveness of using ICT "was not whether computers had an impact on learning but to what use teachers and learners put software and what kind of learning outcomes teachers were trying to achieve". Therefore, this thesis will not address the effects of different types of software, such as ILS, tutorial or drill-and-practice software. Instead, emphasis will be placed on the interactions between learning environment and the generic use of various types of software.

Instructional design and adjustment of instructions

Instructional planning and instructional arrangements are major determinants of the environmental settings for teaching and learning instructions. Some software programs (or software designers) welcome other people (e.g. teachers or learners) to play an active role in instructional design, while some software programs do not welcome other people to take part in instructional design. The instructional design of many subject-specific tutorial or practice software program is completed before the software production stage. In contrast, many generic software programs welcome other people to participate in the instructional design. For example, the user of information search on internet are required to participate in the instruction of retrieval of information. The involvement of teachers or other external people in designing worksheets to be used with a talking word processor is another example. The involvement of other people, other than the instructional designer of the software program, in instructional design can be regarded as additional. The instructional effectiveness of those software programs varies greatly because it is affected by the quality of the instructional design done by the teacher, the pupil and/or another external person.

In applying Vygotsky's (1978) social-interactionist perspective of learning, human-computer interactions provide the 'zone of proximal development' for learners. The effectiveness of using ICT is determined by the success of providing an optimal environment for human-computer interaction. In order to achieve the purpose of providing the best-fitted instructional environment, adjustments of instructions might be needed to cope with the learners' level, pace and style of learning as they are working on the computers. Technology nowadays makes it possible to achieve this purpose. It allows software designers to plan and prepare a range of instructions to be delivered flexibly according to the performance of the learner on the computer. Computer-managed instruction (CMI) and Integrated Learning System (ILS) are typical examples of this type of instruction. Both of them make use of information about the learners' performance and progress as a form of record. CMI places strong emphasis on using the information for management of learning and teaching administration, but ILS stresses the importance of using the information for enhancing the quality of instructions and promoting learning. The former focus is not within the scope of this thesis, but the latter is within the scope of this thesis. This gives further support for including the item concerning ILS in section 4-2-A2 above. As the impact of ILS was recently exploited by various studies and research projects (e.g. Lewis and Costley, 1997; Sizmur et. al., 1998 and Wood, 1998b), no further items concerning the effectiveness of ILS are formulated in this thesis.

Measures of instructional setting, planning and decision-making in this study

Four aspects of instructional setting variables were collected through the administration of a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively. These items are listed in the table below:

Variable	*Samples*	*Item*
apit97	*251*	*Does your weekly planning specify ICT? (Yes/No)*
apit98	*84*	*As above*
apso97	*251*	*Do you plan specific activities to support any computer programs that you use? (e.g. games, worksheets, written work away from the computer) (Yes/No)*
apso98	*81*	*As above*
asac97	*251*	*Do you plan specific computer activities for pupils with special needs? (Yes/No)*
asac98	*84*	*As above*
asad97	*251*	*Do you adapt the use of programs to suit those with special needs? (Yes/No)*
asad98	*84*	*As above*

In relation to the recent trends or movements in the educational use of computers, it was expected that:

- more teachers would specify the use of ICT in their weekly plan,
- more teachers would plan specific activities to support computer programs that they use,
- more teachers would plan specific computer activities for pupils with special educational needs, and
- more teachers would adapt the use of programs to suit pupils with special educational needs.

In relation to the discussions about instructional setting, planning, decision making and instructional design above, it would be sensible to expect that learning outcomes would be positively related to the willingness of the teachers to put effort into each of the four pedagogical and instructional aspects above.

As the sampling was repeated in two academic years, the data concerning each of the aspects above was collected twice. The data collected in 1997/98 would be positively correlated with data collected in 1998/99. As the discussions above suggested that young children might have particular difficulties in using ICT, it was also expected that:

- more teachers in lower primary would plan specify the use of ICT in their weekly plan than teachers in upper primary,
- more teachers in lower primary would specific activities to support computer programs that they use than teachers in upper primary,
- more teachers in lower primary would plan specific computer activities for pupils with special educational needs than teachers in upper primary, and
- more teachers in lower primary would adapt the use of programs to suit pupils with special educational needs than teachers in upper primary.

(4-2-B) The practice of using ICT for teaching / instruction

(4-2-B1) Usage of ICT: frequency, intensity, duration, IT skills/experience and effectiveness

Extent of computer usage and effectiveness of using computers

Further to the discussion about the provision and allocation of ICT resources, we shall focus on the extent of computer usage in daily classroom settings. This includes the actual frequency, intensity and duration of computer use.

The Educational Testing Service in America reported that school computer use at grade 4 was negatively related to academic achievement, but the use of computers for learning games was positively related to academic achievement (Education Testing Service, 1998). In line with this, the report also mentioned grade 8 teachers' use of computers to teach high-order thinking skills was positively related to academic achievement in maths, while the use of computers to teach low-order thinking skills was negatively related to academic achievement in maths.

Sometimes the difference in effectiveness of using computers is due to the quality of instructional design as well as the extent of and the types of computer usage. Inappropriate computer activities, such as too much time spent on mechanical practice-drill tasks for grade 4 children, could have negative effects on achievement in maths. Successful learning activities for children at that age would require consideration of the motivational aspects of pupil learning. Therefore, the reported results could be seen as a positive association between learners' motivation resulting from computer learning games and maths achievement.

Appropriate time length would mean that the length of time is long enough to complete the teaching and learning tasks, without being excessive. Excessive time spent on the computer did not guarantee a better academic output or achievement. For example, in a study of journalism education at higher education level, Renfro and Maittlen-Harris (1986) found that "increasing computer time from one and a half hours to three hours per week did not improve the quality of students' news-writing".

There is evidence to suggest differences in the computer time and effectiveness between different types of computer usage. Findings of the Impact Project suggested that ICT did make a contribution to support the teaching and learning of maths and geography in secondary school and English at primary schools in UK. The extent of the contribution was related to aspects of increased motivation and pupils' interest in using ICT. The contribution was also found to be inconsistent across subjects or age groups (Watson, 1993). A national survey investigating the characteristics of 73 high quality elementary schools known for their support of instructional technology was carried out in 1989. Among the 70% respondents to the survey, it was found that there were three major types of usage of the available computer time. They were:

1. computer applications (29%),
2. computer assisted learning (55%), and
3. computer programming (14%).

It was also found that the three major types of computer activity frequently took place in the classroom. These included:

1. drill and practice (24%),
2. word processing (18%), and
3. tutorials (12%).

The findings were fairly consistent with results of the survey mentioned in the IMPACT project report. The range of software listed by the majority of the classes in the project included tutorial, simulations, games and open-ended software (Watson, 1993). The project report stated that "17% of the primary classes reported using IT once a week, 33% three to five times a term, 33% once or twice a term and the remaining 17% with no IT use" and "67% of the classes having, on average less than an hour per term for each pupil". Pupils' use of computers at school also varied greatly between pupils in different classes, age groups as well as between pupils in the same classes. This showed the existence of unequal access to computers. Another survey in 1995-96 reported that 81% of primary teachers were using computers at least twice a week on average (Xemplar Education, 1998). If the results of the two surveys are comparable, it implies that there was a sharp increase in the use of computers in primary schools at the time before the start of the TTA-ICT project and this PhD study.

McKinsey and Company (1997) reported that many schools were concentrating on applying basic ICT tools across a limited range of subjects, such as spreadsheets for calculations in maths or word-processing in English. It was suggested that widening the vision of computer usage in education, such as the use of content rich software and interactive software. These would include internet, communications, multimedia and integrated learning system software. The extent of its use in subjects other than maths, English and science were much lower than that in major subjects, such as Maths, English or science. The advancement of technology allowed the use of ICT in various subjects, such as music, chemistry, art,...etc.

Measures of frequency, intensity and duration of computer use in this study

Table T4-B2-1a: Variables concerning computer usage frequency, intensity and duration

Variable in 1997/98	**Variable in 1998/99**	**Content of the questionnaire item**
ccom97	***ccom98***	(How often)...does your class use a computer?
pcom97	***pcom98***	How often does a typical pupil in your class get a turn on the computer?
ptim97	***ptim98***	During an average week how much time does a typical child spend on the computer? Please estimate.

Three measures of computer use were collected for this study through the administration of a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively. These included variables concerning computer usage frequency, intensity and duration. These items are listed in Table T4-B2-1a above.

In relation to the discussions above, it was expected that:

- data collected in these two years would be correlated with each other, and
- there would be an increase in each of the three aspects of computer use, from 1997/98 to 1998/99.

As discussed in section 4-2-A1 and section 4-2-B1, compared with pupils in upper primary, pupils in lower primary were expected to:

- have a higher frequency of class computer usage, and
- have more opportunities to have a turn on the computer.

Compared with pupils in upper primary, pupils in lower primary were expected to be able to spend a shorter duration of time on the computers in an average week.

The discussion in section 4-2-A1, section 4-2-A3 and section 4-2-B1 suggested that the effectiveness of using computers was a complicated issue, which is not only affected by a single factor such as the provision of equipment, the quality of the software programs, the extent of usage. Instead, the instructional arrangements, or the pedagogy concerning its use is a crucial factor affecting its effectiveness. So, it would be sensible to expect that pupils' learning outcome would be related to each of these three measures concerning the extent of usage although caution would have to be paid to the positive or negative nature of the impact. This means, investigation concerning these relations needs to be considered in a bi-directional way. Statistical tests to be used have to be two-tailed, rather than one-tailed tests.

Teachers' IT knowledge/skills, pupils' experience in using ICT at home and the effective use of ICT in primary education

In the report of a project carried out by the National Research Council in the US, the committee on information technology literacy outlined the reasons for the need of fluency with information technology. The term "fluency" indicates the ability to reformulate knowledge, to express oneself creatively and appropriately, and to produce and generate information, and not only to comprehend it (National Research Council, 1999a). Alternatively, the concept is also commonly named as "computer literacy", which includes the IT knowledge and skills of individuals.

In order to operate computers effectively for learning purposes, teachers and pupils in primary education need to develop adequate computer knowledge and skills. Inadequate computer skills/experience might hinder them from teaching and learning tasks supported by the computer. The development of computer knowledge and skills are greatly determined by the opportunity to practise on the computer, together with proper practising instructions. For example, Steele et. al. (1983) examined the effects of computer assisted instruction on the development of computer literacy with 86 fifth grade students. The results showed that their computer literacy improved significantly. Battista and Steele (1984) reported the results of another study of the effects of computer assisted instruction (CAI) on the knowledge and feelings about computer literacy of 72 high-ability fifth grade students. CAI was found to be effective for improving their computer literacy in the cognitive and affective domains. It might be worthwhile to note that the opportunity for a primary pupil to access the computer is determined by the links between the number of computers available and the number of users. The higher the pupil-to-computer ratio, the lower the opportunity for a typical pupil to access the computer. It would likely be a hindrance to their IT skills development. This would imply that pupils' development of IT skills and experience could be related to other pedagogical and instructional variables. For examples, in a research of two groups of grade 4 pupils in Indiana, the group with a student/computer ratio of 2:1 had significantly higher scores on the computer skills test than the group with one computer available to the class (Gilman & Brantley, 1988).

There is evidence suggesting the effects of in-service training on the improvement of practising teachers' computer "literacy" or "fluency". For instance, Burmeister (1992) reported the amount of computer usage of teachers and students differed from grade to grade and from classroom to classroom. A grade level specific computer literacy curriculum was introduced and implemented through elementary school teacher in-service training. Analysis of the data from a survey of teachers suggested that "the participants in the individual in-service sessions were able to use the computer to produce a product and/or explore the use of the computer in a new way". In a recent project carried out by the National Research Council in the US, 30 high school teachers participated in an in-service computer literacy course in Pennsylvania. A significant improvement in the knowledge of and attitudes toward microcomputers was found by comparing the participants' results in The Minnesota Computer Literacy and Awareness Assessment before and after the course (National Research Council, 1999a).

To conclude, the frequency, intensity, duration of using computers as well as the users' IT skills and experience are greatly limited by the provision of computer equipment. The inconsistency and insufficiency of equipment provision in primary schools are major barriers or limitations for effective computer use. Furthermore, it is necessary to work on the computer literacy of students and that of teachers. In other words, there is a need to equip society with human resources so that the use of hardware and software can be focused on various educational aims, as defined by the curriculum. In line with this, clear objectives were set in the initial teacher training National Curriculum for the use of information and communication technology in subject teaching. It stated, "to equip every new qualified teacher with the knowledge, skills and understanding to make sound decisions about when, when not, and how to use ICT effectively in teaching particular subjects" (TTA, 1998).

Measures of IT knowledge/skills and experience in this thesis

Only one item concerning pupil IT skills and experience was asked in the teacher questionnaire in the academic year 1997/98. The item is illustrated as follows:

Please estimate the percentage of pupils in your class who use a computer at home. (___%)

Five sets of measures on teachers' computer skills/experience were collected through the administration of a teacher questionnaire in the academic year 1998/99. These include measures of basic computer operation skills, word-processing skills, spreadsheet skills, database skills and internet skills. Respondent teachers were asked to rate their own IT skills/experience in each item according to the scale 1 to 5, starting from "low" to "high" (please refer to section 4-4-B1 for statistics assessing the internal consistency of the five scales). The five aspects of computer skills/experience were common aspects of computer skills/experience required for educational purposes. These items are illustrated as follows:

Basic computer skills: How **experienced** are you at.... (Low...High)

Installing software from disc or CD

Manipulating files e.g. saving, copying, deleting, renaming

Formatting a 'floppy' disc

Creating directories and moving files

Word processing skills: How **experienced** are you at.... (Low...High)

Cutting and pasting information

Using a spell checker

Adjusting page layout and printing

Creating tables

Spreadsheet skills: How **experienced** are you at...... (Low...High)

Using formulae e.g. add up a column

Creating graphs

Printing only a specific area of the spreadsheet

Creating simple list e.g. a class register

Database skills: How **experienced** are you at... .... (Low...High)

Developing a simple database e.g. an address book

Importing data from other sources

Using a library catalogue (not a paper based one!)

Finding the required information following a search

Internet/World Wide Web skills: How **experienced** are you at... .... (Low...High)

Finding information using a search engine

Saving text & images to use in other software packages

Sending e-mail messages

Creating web pages

In relation to the discussions in section 4-2-A1 and section 4-2-B1, it was expected that:

- a higher percentage of pupils in upper primary who use a computer at home than those in lower primary,
- teachers in upper primary would have a better IT knowledge and skills than teachers in lower primary,
- the percentage of pupils in upper primary who use a computer at home would be positively related to learning outcomes, and
- teachers' IT knowledge and skills would be positively related to learning outcomes.

(4-2-B2) Quality and appropriateness of instruction: the use of computers for curricular teaching and learning

In section 4-2-A3 above, we have reviewed the importance of instructional setting, planning and decision-making on the use of ICT to support effective teaching and learning. To achieve an effective use of the computer for teaching and learning purposes not only requires the planning and organisational skills of the teacher, but also the knowledge related to its use, such as the potential and pitfalls of using ICT to support the curriculum, the links between ICT and the characteristics of pupils. Besides these factors, the appropriateness of instruction is also an important factor affecting the quality of instruction (e.g. Slavin, 1995). We shall look at the focus of instructional use of the computer in the paragraphs below.

The use of computers for teaching and learning purposes

Computers can be used for various purposes. For instance, as a tool for accounting, administration, management, organiser and storage of information, ...etc. In applying the capability of IT in education, BECTa (1995) described IT as "a feature of all areas of the curriculum and will play a significant role in a broad and balanced provision". SOEID (1999) mentioned four types of usage of ICT in education, these included:

- classroom use,
- professional development (for teachers),
- personal use (for teacher), and
- administration.

Instead of working on various types of usage of computers in education above, the scope of this study is limited to classroom usage, as this makes a direct contribution to the learning process or outcomes. This will include the use of portable computers as a form of "out-of-school" learning, while the definitions of "extended classroom" is incorporated within the scope of the thesis. In other words, the use of computers to facilitate the productivity of teachers or pupils, which makes an indirect contribution to the learning process or outcomes, will be out of the scope of this thesis. According to the educational functions, two typical sub-types of classroom computer usage will be addressed in this thesis:

1. for teachers' use, as a medium for teaching, and

2. for pupils' use, as a support for the learning and instructional needs of the curriculum.

In fact, the first type of usage tends to be teacher-centered, while the latter type tends to be pupil-centered. The general trend of educational movement in the last thirty years indicates a shift away from the former towards the latter (e.g. Bigge & Shermis, 1992). When referring to the use of computers in primary schools in UK nowadays, some uses of computers bear the characteristics of both. For example, when the computers are used for drill and practice or tutorial activities, they function as a tool for learning as well as a medium of instruction. We shall come back to literature about the classification of usage after the next section.

The use of computers for teacher presentation

Using computers for teacher presentation seemed to be a typical activity of the first type of usage. There are various studies on the effects of this type of usage. Rivers (1972) described the success of a computer-assisted presentation. In the report, "decision logic" was suggested as a good means of identifying individual learner needs because it helped monitoring the within-course progress of the college students involved and facilitated the detection of the group of students who needed assistance. Brown (1998) demonstrated the successful use of "Kid Pix" software to support classroom instruction for kindergarten through to second grade pupils. The software is easy to handle by teachers as well as by pupils with training and technical assistance. Sussman and Lowman (1989) used computers for presentations or simulations of human interactions. Computers were found to be superior to hardcopy among students in higher education. They rated the computer-supported presentation more satisfying than hard-copy, in terms of the effects of realism and perceived control. Similarly, the research done by Avitabile (1998) also found the group of post-secondary students receiving hypermedia presentation did better than the group receiving traditional lecture presentation, although he failed to find the existence of interaction between the effects of presentation mode and learning style. Riffee's (1991) liquid crystal display (LCD) technique enabled classroom viewing with a large screen. It enhanced the presentation in higher education setting. In fact, technology today allows the content of the computers to be displayed on a large screen enough for viewing by all the pupils in class in an affordable price for most schools. Burgmeier and Kost (1993) also described the implementation of a computer projection system for medium to small classrooms at the University of Vermont. Features of the system included the ease of use, compatibility, software, and network capability and possibility of adding other support equipment.

The results of previous studies did not always favour the use of computers for teacher presentation. Wilmoth and Wybraniec (1998) mentioned the profits as well as pitfalls of using a portable computer for teacher presentation in higher education. McGoldrick et. al. (1992) used the computers to present discrete information in text and concluded that it was less efficient than presenting in printed text. Noonen & Dwyer (1994) investigated the order of visual presentation and choice of review. They did not find a significant impact of the computers on achievement of students. Similarly, Sherwood and Hasselbring (1984) did not find any difference between the following modes of presentation supported by the computers:

(1) two students per computer interacting with the simulation,

(2) a total class presentation of the computer simulation, and

(3) a non-computer game-type presentation of the simulation concepts.

To conclude, the literature review on the successful use of computers for teacher presentation indicated that it has good potential contribute to pupil learning. There is evidence to show that it benefited learners with better comprehension of the subject content, better learning achievement, increased their motivation or concentration on the learning activity, increased their control and involvement in the activity and increase their social interactions (e.g. Schacter, 1999; Niemiec and Walberg, 1987; Kulik and Kulik, 1986). Furthermore, the latest report of ImpacT2 project also provides a review of the findings of recent research in this area (McFarlane, 2000). Generally speaking, its effectiveness depended on the context of use, the quality of instruction and the characteristics of the learners e.g. gender groups, IT skills. Technology also has its own limitations. For example, computers are weak in presenting content with discrete information.

Subject focuses concerning the use of computers in the curriculum

To achieve specific classroom teaching and learning objectives, computer activities are used in the context of other classroom activities. This provides a rationale for the integration of computers into the curriculum of primary education. By doing this, the use of computers becomes a planned or systematic practice. In relation to the subject areas of the curriculum, there are two subject focuses emphasised in the integration, these include:

1. Using computers to support subject teaching, and
2. Using computers to improve on pupils' ICT knowledge and skills.

The former is the major focus of this study. The latter is included as a complementary focus of interest because of its close relation with the former. Pupils' computer knowledge and skills are important factors for successful learning with activities supported by computer. Nowadays teachers sometimes combine the two focuses above. The extent of the combination varies greatly between schools and it is greatly affected by the policy that a particular school has adopted. Plomp (1989) has described two distinctive approaches to computer education in the Netherlands. Computer skills training was either presented by separate computer literacy courses or a mix of the teaching of computing via traditional subject matter courses. The results of trend analysis in Plomp's study showed a remarkable overall shift from the former approach to the latter. On the other hand, a recent teacher survey by SOEID (1999) reported that ICT was "still seen as an extra or add-on rather than an integrated resource within teaching" and many teachers were "still concerned with 'teaching ICT' rather than 'teaching with ICT'". On this basis, when referring to the approaches to IT capability in the UK, NCET (1995) suggested, "IT activities can be planned separately, or within a subject context. This will depend on the planning mechanism used. It is, however, important to identify clearly what the IT is to be used for: 'to draft and edit a report of an experiment', rather than 'use a word processor'; or 'access information for a particular purpose', rather than 'use a database'."

Using computers to support learning activities

Papert and Solomon (1971) suggested twenty learning activities that students in elementary schools could do with the use of a computer. The authors stated that computers could be used to:

- move a machine called a Turtle in geometric patterns,
- play games,
- draw diagrams,
- make movies,
- program musical instruments,
- compose music,
- computerize erector sets,
- make light shows,
- write poetry,
- teach physics, and
- control puppets.

These were examples of activities that were supported by computers thirty years ago. SOEID (1999) reported that word-processing was the most frequent activity in primary and secondary schools in Scotland. With recent advances in technology supported by computers, it was expected that there could be a wider range of teaching and learning activities supported by the computers. However, in the TTAICT project, most teachers reported using ICT in a limited number of ways. The two teacher surveys of the TTAICT project addressed a list of 13 activities in which ICT was used in the classroom. These activities included: demonstration to the whole class, activity at play time, as a reward, as an extension work, as extra support for some pupils, information retrieval, analysing patterns and interconnections, practice basic skills, word-processing, number work, free choice activity, project work and activity when they have finished class work.

Measures of curriculum use of computers

Thirteen items concerning the type of computer use were asked in a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively. The items are listed as below:

Please tick a box to show approximately how often you use computers in your class for the following purposes:

[in %]	***Less than once a fortnight***	***Once a fortnight***	***Once a week***	***Once a day***	***More than once a day***
To demonstrate something to the whole class					
For pupils to use at play time					
As a reward					
As extension work					
As extra support for some pupils					
For information retrieval					
For analysing patterns and interconnections					
To practise basic skills					
For word-processing					
For number work					
As part of free choice activities					
For pupils to use when they have finished classwork					
For major project work					

In a survey in 1998/99, there were two items asking about the subject focuses in using computers, including using computers for the development of IT skills and for the support of subject learning. These items are illustrated as below.

Please tick the appropriate box to show the extent to which you use ICT:

to focus on ICT skills development			
0-24% of the time	*25-50% of the time*	*51-74% of the time*	*75-100% of the time*

Explicitly to support subject teaching (i.e. all curriculum subjects except ICT)			
0-24% of the time	*25-50% of the time*	*51-74% of the time*	*75-100% of the time*

Further to the discussions above, it was expected that:

- the data collected in survey 1997/98 would be positively correlated with the data collected in survey 1998/99,
- the frequency of each type (and sub-type) of usage would increase during the two academic years, and
- there might be discrepancies in each sub-type of curriculum use of computers between upper and lower primary classes.

In other words, the last point above suggested that different patterns of curriculum usage of computers was expected between upper and lower primary classes. As it was an exploratory attempt and it did not make assumptions about the direction of the difference, it was appropriate to use two-tailed statistical tests. It was also expected that the frequency of using computers for each type of curriculum purpose would be positively related to learning outcomes.

In relation to the discussion about subject focuses above, it was expected that:

- teachers' rating for the use of computers for developing pupils' IT skills would be positively related to their rating for the use of computers for supporting subject teaching,
- teachers' might give a higher rating for the use of computers for supporting subject teaching than for the use of computers for developing pupils' IT skills, and

- teachers' ratings for the use of computers for developing pupils' IT skills or for supporting subject teaching would be positively related to pupil learning outcomes.

(4-2-B3) Additional instructional support: adult helpers in class

Teachers and computers are two major sources of instruction in the classroom. Often adult helpers in class may be another source of instruction in the classroom. In early years classrooms, it is not uncommon to find other adults helping in the classroom. The adults may include nursery nurse, teacher trainee, parent helpers, voluntary workers, helpers or visitors from other organisations, and other personnel in the school. For instance, a child with SEN may require help from another adult in class for language or emotional difficulties. In most of the nursery classes in the UK, the ratio of the number of adults in class and the number of children is fixed at 1 to 13. Besides the class teacher, the statute requires other staff helpers in the classroom e.g. nursery nurse. We shall discuss more about some other types of support concerning the use of ICT in the next section.

Measures of adult helpers available in class

Table T4-B2-3: Teacher questionnaire item concerning adult helpers

Variable	*N*	***Item***
adul97	*247*	*Do you regularly have other adults helping you in class? (Yes/No)*
adul98	*81*	*as above*

Key: *N* refers to the sample size

Only one item concerning the availability of an adult helper in class was asked in a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively. The item is listed in the Table T4-B2-3 above.

In relation to the description above, it was expected that:

- the data concerning adult helpers collected in 1997/98 would be positively related to the respective data collected in 1998/99,
- there might not be a statistical difference in the means of the data concerning adult helpers collected in both years,
- there would be more adult helpers in lower primary than in upper primary, and
- the availability of other adults to help the class regularly would positively affect the pupil learning outcomes.

(4-2-C) Perception of feedback regarding learning and instruction

With proper instructional design, computers nowadays can provide excellent feedback about learning and about the success of instruction. Modern computers have very good memory and they can record abundant information about the learner's personal characteristics and about his or her performance in learning. The information can be used as feedback to formulate instructional adjustments according to the learner's performance and characteristics. Computer-managed instruction (CMI) and integrated learning systems (ILS) are typical examples of this type of instructional design. The feedback is fast and accurate, and the formulation of instructional adjustments is performed automatically. The instructional design allows learners to access learning activities at their own level, pace and style of learning. This could reduce the time spent on repeating learnt activities, avoiding redundant information and maximising pupil-computer interaction. That means, instructional planning, instructional arrangements, perception of feedback, and instructional adjustments are inter-related. As shown in the model of curricular teaching and learning supported by ICT in Chapter 2, the whole mechanism determines the quality of teaching and learning.

Nevertheless, teachers are responsible for all the instructional arrangements in the classroom and the effectiveness of learning and instruction, including those when computers are used. They need feedback about pupil learning and instruction. With particular reference to the effects of using computers, teachers may obtain feedback from CMI, ILS or other computer software programs that have records about pupil learning. Teachers may also obtain feedback from other evaluations and assessments in non-electronic formats. Readers need to note that it is not always possible to distinguish the effects of computer-related activities from the effects of non-computer related activities because the two types of effect interact with each other. Having said that, it is widely accepted that a positive effect concerning the use of computers perceived by the teacher would be likely to encourage the use of computers by that teacher in the near future. On the contrary, a negative effect concerning the use of computers perceived by the teacher would be likely to discourage the use of computers in the future. The paragraphs below will discuss the discrepancy between the actual effects and the perceived effects, and a proposed mechanism explaining how teachers tackle the challenges of using computers or ICT in primary classrooms.

(4-2-C1) Perceived effects concerning the use of computers for teaching and learning

In chapter 2 and chapter 3, we have reviewed the literature related to the potential, pitfalls and the effects associated with the use of computers. The effects on pupil learning can be summarised in these three domains: cognitive, affective and psychomotor. When the teacher perceives the effects on pupil learning, this functions as a form of feedback. In applying behaviourist learning theory, the perception of positive effects reinforces the use of computers in the future. It is worthwhile to note that there is a discrepancy between the actual effects and the perceived effects, although the gap could vary from very small to very large. It often takes time for the teacher to know the existence of an effect, if there is any. This is one of the possible explanations for the discrepancy. Unperceived effects, no matter how large the effect sizes are, may not have any impact on the teacher's future behaviour in using computers. The perception of effects associated with the use of computers is also affected by other affective and emotional factors, such as the teacher's personal attitudes, expectations and awareness. This means, it may happen that the teacher may perceive an effect that does not really exist, but the perceived effect could still have an impact on the teacher's behaviour. Rather than just focus on the actual effects alone, therefore, there are reasons for investigating the perceived effects. Data concerning three aspects of perceived effects on the use of computers were collected for this study. These include teacher's perceived effects on pupil academic achievement, pupil learning attitude and teacher's workload.

Measures of perceived effects

Three items concerning the perception of effects of the classroom use of computers were asked in a teacher questionnaire in the academic year 1998/99. These include the perception of effects on pupils' academic achievement, pupils' attitude towards learning and the teacher's perception of workload resulting from the use of computers. These items, and the response choices given, are listed as below.

Please tick the appropriate box to show your perception about the change in pupils' academic achievement since autumn 1997, due to the use of computers to support subject teaching.

Improved	*No difference*	*Declined*	*Not sure or impossible to give an answer*

Please tick the appropriate box to show your perception about the change in pupils' attitude towards learning since autumn 1997, due to the use of computers to support subject teaching.

Improved	*No difference*	*Declined*	*Not sure or impossible to give an answer*

Please tick the appropriate box to show how the use of ICT to support subject teaching (i.e. all curriculum subjects except ICT) affected your workload when compared with teaching without the use of ICT.

Increased a lot	*Increased*	*No difference*	*Decreased*	*Decreased a lot*	*Not sure or impossible to give an answer e.g. not using ICT at all*

It was expected that:

- teachers' perception of academic achievement resulting from the use of computers to support subject teaching would be related to their perception about their change in attitude towards learning,
- the mean of teachers' perception of academic achievement resulting from the use of computers to support subject teaching might differ from the mean of their perception about their change in attitude towards learning, as they refer to different types of learning outcome,
- teachers in upper primary might have a better perception of the change in pupil achievement or attitude resulting from the use of computers to support subject teaching,
- teachers in upper primary might have a better perception of the workload resulting from the use of computers to support subject teaching,
- teachers' perception of change in pupil achievement or attitude achievement resulting from the use of computers to support subject teaching would be positively related to pupil learning outcomes, and
- teachers' perception of workload achievement resulting from the use of computers to support subject teaching would be positively related to pupil learning outcomes.

(4-2-C2) Perceived challenges: favourable and unfavourable factors concerning the use of computers for teaching and learning

There are many factors that affect the use of computers for teaching and learning purposes, including favourable and unfavourable factors. A set of measures was constructed as a composite measure of the impact of these factors when being viewed as perceived challenges.

Measures of perceived challenges concerning the use of ICT

In the teacher questionnaire administered in the academic year 1998/99, there were eighteen items concerning perceived challenges of using ICT. These items were used to explore the dimensions and the structure of various factors affecting teacher's usage of ICT, including favourable and unfavourable factors towards its use. The details about the given choices are described in section 4-4-C2. These items are listed as below:

Variable	***Content of the questionnaire item***
chl_01	*The age of my pupils.*
chl_02	*My knowledge and skills about hardware.*
chl_03	*Equipment available for pupil to use.*
chl_04	*The ability of my class.*
chl_05	*My knowledge and skills about software.*
chl_06	*The number of pupils in my class.*
chl_07	*Access to information about hardware and software at school.*
chl_08	*Technical support available in school.*
chl_09	*My knowledge about how and when to use ICT.*
chl_10	*Reliability of available equipment.*
chl_11	*My interest in the classroom use of ICT.*
chl_12	*Availability of adults to help pupils on the computers.*
chl_13	*My expectation about the educational outcome of using ICT.*
chl_14	*The demands on teachers' time and effort in class.*
chl_15	*The impact of school/educational policy e.g. literacy or numeracy hour.*
chl_16	*Time and effort for planning and preparation.*
chl_17	*The supervision of pupils' learning on computer.*
chl_18	*My knowledge and skills in planning follow-up work.*

In relation to the section 4-2-B1, section 4-2-B2 and section 4-2-C2 above, it was expected that the extent of challenge perceived by teachers in upper primary would be higher than the extent of challenge perceived by teachers in lower primary.

(4-2-C3) Inclination towards using computers in the classroom

In section 4-2-C2 above, we have discussed the challenges of using ICT by linking favourable and unfavourable factors towards using ICT. The major purpose of that section was to explore the dimensions and structure of various factors affecting teacher's usage of ICT. In this section, we try to put forward a set of measures of teacher's inclination towards using computers. It was expected that there would be close alignment between the two measures. Challenges are negative attitudes towards the use of computers, while inclination towards using computers is positive.

Teacher's inclination towards using computers in the classroom differs from the actual frequency, intensity or duration of computer use. It is a combination of various practical judgements about the use of computers made by teachers at the pedagogical and instructional decision making stage. In their practical working environment, teachers often have to consider favourable and unfavourable factors affecting their use of computers. These include the teachers' interest, initiative and motive to use computers as well as various challenges and support concerning the use. The pedagogical and instructional consideration processes involve a lot of practical judgements. Teacher's inclination towards using computers is the product of these practical judgements. For Schon (1983), the practical judgements made is the reference for the teachers' behaviour in practice, which is known as their "theory-in-use".

The measure of teacher's inclination towards using computers is a composite measure that can be viewed as the teacher's overall pedagogical judgement concerning the use or not use of computers in the classroom. Unlike teacher's conception, belief, preference or theoretical knowledge that acts as a part of the teacher's characteristics, teacher's inclination towards using computers is comprised of many practical considerations towards the use of ICT. The measure includes the teacher's personal expectations, interest, concerns and the difficulties encountered or to be tackled concerning the use of ICT, and it also includes various challenges and supports concerning its use in their own practice environment.

Measure of inclination towards using computers in the classroom

ID	Content of the questionnaire item	Valid N
1	My school has a plan to develop the use of ICT across the curriculum.	68
2R	In my school, there is not enough information about published educational software.	69
3	I think the educational use of ICT is cost-effective.	68
4R	It is hard to include computer work in most sessions.	68
5R	My pupils do not have adequate keyboard skills for using computers.	68
6	Computers make me feel good about my teaching.	66
7	I know that parents are generally positive about the educational use of computers.	67
8R	It is hard to monitor pupils' learning on computers.	69
9R	I find that most software is not appropriate for the National Curriculum.	68
10	I am keen on the educational use of ICT.	68
11R	Most software is too complicated for my pupils to use.	68
12R	It is difficult to plan follow-up work for computer activities.	69
13R	For me, planning a computer-supported lesson is too time-consuming.	68

The 1997/98 teacher questionnaire included a set of 13 questionnaire items about teachers' inclination towards the use of ICT in the classroom. Respondents were asked to rate the extent of their agreement to each aspect about using ICT with "strongly disagree", "disagree", "not sure", "agree" and "strongly agree". The content of these items can be found in Table T4-B3-3a. In order to identify items that required a reverse of the direction of the scale, an "R" was put in the respective cell in the ID column. For pragmatic reasons in the TTAICT project, only five of these items were repeated in the second questionnaire in 1998/99, with a three-point scale of measurement. As a parallel version of the previous set of questionnaire items was needed for comparison purposes, these items was asked in the third questionnaire sent in Autumn term 1998/99. The number of valid responses obtained in 1997/98 and 1998/99 was 226 and 68, respectively.

It was expected that:

- the data collected in both academic years would be positively correlated,
- teachers might have a stronger inclination towards using computers in 1997/98 than their inclination towards using computers in 1998/99, and
- teachers in upper primary would have a stronger inclination towards using computers than teachers in lower primary.

As teachers' inclination towards using computers was expected to be linked with the extent of challenges they perceived, it was expected that measures of teachers' inclination towards using computers would be negatively related to the extent of challenges they perceived.

It was also expected that teachers' inclination towards using computers would be significantly correlated with various measures of learning outcome. Statistical investigations on this issue have to be two-tailed because the impact of use is uncertain, as mentioned in section 4-2-B1.

(4-2-D) Teacher's personal characteristics and professional development

In the sections above, we have addressed the potential impact of pedagogy and instruction on the effectiveness of teaching and learning supported by computers. In this section, we shall take a step backward by looking at a group of factors affecting pedagogy and instruction. This group of factors is defined as the personal characteristics of the teacher. Literature about teacher education and professional development (e.g. Shulman, 1986; Cullingford, 1995) suggests that they impact on the teacher's pedagogy and instruction. In the paragraphs below, we shall have a brief discussion of the connections between the relationships between the pedagogy or instruction concerning the use of ICT and each of the following aspects of teacher characteristics. These include: teachers' experience, subject knowledge, their interest in computers, their conceptual preferences and their reflective practice.

(4-2-D1) Experience and subject knowledge

So far, we are not sure if pedagogy is the major factor affecting educational achievement. Cohen et. al. (1996) stated that there is an on-going debate on the importance of "pedagogy" and "subject knowledge" in the effectiveness of learning and instruction. These include arguments for improving the subject knowledge of the teacher (e.g. Bennett & Carre, 1993; Bennett, Wragg, Carre & Carter, 1992) and arguments for improving the pedagogical knowledge of the teacher to raise standards (e.g. Galton & Simon, 1980; Galton, Simon & Croll, 1980). Many people believe that a teacher's experience makes a contribution to pupil achievement. In contrast, some people believe that experienced teachers often work on a routine basis, and there is no clear link between teacher experience and pupil achievement. In the formulation of a model for predicting effectiveness of teaching and learning supported by the use of ICT, teacher experience has to be taken into consideration. In this thesis, there is no direct assessment of teachers' subject knowledge. The closest measure that relates to teacher's subject knowledge is an item in the survey asking the teacher to report whether he or she is a co-ordinator of English, Maths and IT, respectively.

Measures of teachers' experience and subject knowledge

An item measuring teachers' experience and responsibility in being a subject co-ordinator of a specific subject was asked in a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively.

Variable	*Samples*	*Content of the questionnaire item*
aax97	*245*	*How many years have you been a teacher, including this year?*
aax98	*44*	*as above*
aax98e	*241*	*as above (formulated by combining data of the two variables above)*
acit97	*251*	*Are you the IT co-ordinator for your school? (Yes/No)*
acit98	*84*	*as above*
acen98	*62*	*Are you the English co-ordinator for your school? (Yes/No)*
acma98	*62*	*Are you the Maths co-ordinator for your school? (Yes/No)*

It was expected that:

- the data concerning the role as an IT co-ordinator for the school collected during the two academic years would be consistent,
- there would be no statistical difference between the two measures above, and
- there would be more IT co-ordinators teaching in upper primary than in lower primary.

It was also expected that pupils' performance were affected by the following teacher-related variables:

- teachers' experience,
- being an IT co-ordinator for the school,
- being an English co-ordinator for the school, and
- being a Maths co-ordinator for the school.

(4-2-D2) Teachers' interest, conceptual preferences and reflective practice

Personal interest in computers

Further to the issues concerning teachers' computer skills/experience and the use of computers in the classroom discussed in section 4-2-B1 above, this study also aims to consider the impact of teachers' personal interest in computers. To a certain extent, the measure of teachers' interest in computers might have some links with teachers' IT skills/experience. The links may include similarities and differences. For instance, it is likely that a teacher with good IT skills/experience will have a positive interest in computers. On the other hand, a teacher who is aware of the lack of computer skills/experience might also have positive interest in computers. The awareness may lead to an increase in the frequency, intensity or duration of using computers for learning and development purposes.

Measure of personal interest in computers

An item measuring teachers' personal interest in computers was asked in the 1998/99 teacher survey. Here is the illustration of the item:

Please tick the appropriate box to show your ***attitude toward computers:***

Strongly dislike them.	*Dislike them.*	*Not sure (try not to use this box)*	*Like them.*	*Strongly like them.*

It was expected that:

- upper primary teachers' attitude towards computer would be more positive than lower primary teachers', and
- teachers' positive attitude toward computers would make a positive contribution to pupil performance, with the use of computers or ICT to support teaching and learning.

Pedagogical and instructional preferences

There is research evidence suggesting that teachers' beliefs or conceptions have an impact on their approach to teach and the quality of pupil learning (e.g. Kember, 1997; Pajares, 1992; Biggs, 1989). Loveless (1995) states that "the way in which we plan, organize and manage activities in the classroom reflect our beliefs about and aims for the children's learning". So, teachers' beliefs or conceptions have a role to play in their pedagogy and instruction because they are the basis of practical judgements during the pedagogical and instructional consideration processes.

Personal construct theory is a personality theory that has had an increasing impact on educational research in the last 50 years. The idea of personal constructs was proposed by Kelly (1955) to describe the basic units of analysis of personality. Personal constructs are the representation units that we use to conceptualise and to extend our ideas of the environment. We use these personal constructs to make predictions about events and to form mental rehearsals for ourselves before the actual things happen. Kelly suggests that the constructs that are created by individuals may be 'bi-polar' in nature. That means, they might be expressed in contrasting concepts, such as 'good and bad' and 'happy and unhappy'.

Pedagogical preference is an aspect of personal characteristic formulated when the teacher applies his or her beliefs in making pedagogical and instructional choices. For example, with the concept that teaching is a student-centred activity, a teacher may prefer activities that are controlled by pupils to activities that are controlled by the teacher. The extent of preference might be shown when the teacher is given a task that requires him or her to indicate her choice along a line with the two contrasting concepts 'pupil control' and 'teacher control' at the ends. The use of a linear bipolar scale to measure teachers' pedagogical preference is not new. Martin Cortazzi has used this type of instrument to demonstrate the polarities in teachers' thinking (Cortazzi, 1991). He thinks teachers generally accept that both poles are necessary. Pedagogical preference is determined by the tensions of the two contrasting teaching dimensions or strategies of work that a teacher can use to handle a conceptual or a practical issue about teaching. To deal with the issue, the teacher needs to make a pedagogical judgement in deciding the extent of preference of the two contrasting dimensions or strategies of work. The preference is relative in nature. The stronger the preference of one dimension or strategy of work will mean the weaker the preference of the contrasting dimension or strategy of work.

Measures of pedagogical and instructional preference

In referring to our discussions above, the teacher's choice is strongly affected by his or her beliefs or conceptions. The task on a bipolar scale is a practical exercise constructed on the basis of personal construct theory and the pedagogical and instructional preference is the focus of measurement in this study. An instrument was constructed and administered for the TTAICT project and for the purpose of this thesis. The instrument was constructed on the basis of the results of a teaching conception elicitation exercise designed for primary school teachers involved in the TTAICT project in 1997/98 and the size of the data collection was extended in 1998/99. In each item of the exercise, teachers were given three cards that contained statements about teaching. They were asked to choose a pair of cards that appeared to be similar to each other. The last card was a card that seemed to be independent or dissimilar to the other two cards. Teachers were also asked to explain the reasons for the similarity and difference. For example, when commenting on an item about the subject focus of the curriculum, teachers might state that two of the cards were related to numeracy, while the last card was related to literacy. Therefore, each of these items would elicit an aspect of pedagogical thinking. The outcome of this exercise was a database about the set of conceptions that the teachers had used.

There were 70 items in the instrument about teachers' pedagogical preferences. A self-rating exercise was then carried out. Each of the items comprised of a straight line, with a pair of contrasting strategies presented at the two ends, respectively. Teachers were asked to put an "X" on the line to indicate the extent of their pedagogical preference for a dimension or strategy of work as opposed to the contrasting dimension or strategy of work. For example, in an item about the subject focus of the curriculum, the word "numeracy" and "literacy" might appear at the two ends of the line. A teacher who put a cross very close to the "numeracy" end would mean that the teacher strongly preferred numeracy to literacy. The extent of preference was measured on a twenty-five point linear scale.

The instrument in this study is used as an exploratory tool to identify some distinctive dimensions of pedagogical and instructional preferences. Among the 70 items of the instrument, 5 dimensions were identified. Finally, measurement scales were formed from 20 items of the instrument. They were:

1. A preference for not using ICT as opposed to using ICT.
2. A preference for teacher control as opposed to pupil control.
3. A preference for closed activities as opposed to open activities.

4. A preference for individual activities as opposed to collaborative activities.
5. A preference for teaching language as opposed to teaching maths.

The formulation of the five measurement scales follows a few screening steps. Firstly, a review of the content of questionnaire items and grouping of items into categories. Five categories of pedagogical and instructional preferences were identified. Each category contained four to six survey items. Then items on each scale were tested against their internal consistency. The best sets of 4 items were kept for each measurement scale. Finally, these 20 items of the instrument were validated in an exploratory factor analysis to test against their 5-factor structure. The results of analysis showed that the expected 5-factor structure clearly exists among the selected items. Details about the statistics concerning its internal consistency are reported in Table T4-D4-2b in section 4-4-D2 below.

It was expected that:

- teachers in lower primary would have a stronger preference for not using ICT as opposed to using ICT, and
- each of the five sub-scales of pedagogical preference would make a contribution to pupil performance, and to the use of computers or ICT to support teaching and learning.

Professional development: teachers' reflective learning and practice

In the above paragraphs, we have mentioned the role of refection as a bridge between teachers' pedagogical preference and their pedagogical practice from the perspective of professional development. We shall look further at the relationships between teachers' reflection and their pedagogical and instructional practice when ICT is being used. The relationships seem to be essential, as Loveless (1995) asserts that "it is not possible to consider the use of IT in classrooms without reflecting upon one's beliefs about learning and teaching".

Underwood and Underwood (1990, page 4) stated, "The computer is not a passive addition to the classroom; it is not a neutral black box. It is versatile, and because of its ability to support many educational philosophies it forces us to reflect actively upon which form of education we want for our children. After all, we have never asked whether or not a blackboard or a book will replace the teacher, but we do ask that question about computers. At intellectual, social, economic and pragmatic levels, computers are a challenge to current educational practice." The statements imply that the challenge of using ICT requires teachers to reflect on their own pedagogical and instructional practice. A reflective teacher would be better at learning from practical experience of their own and/or that of others. At an exploratory understanding level of learning, reflection is an important step for tackling pedagogical and instructional challenges in the classroom, including those when ICT is being used and those when ICT is not being used. Further details about the theoretical background concerning reflection will be addressed in Chapter 5. Four modes of reflective thinking and actions will be used in the formulation of a statistical model predicting the effectiveness of teaching and learning supported by ICT.

Measures of reflective practice

Data concerning the four modes or categories of reflection are collected from a teacher questionnaire carried out in 1998/99. Four measurement scales are formed from a total of 14 items. The respective items are listed in Table T4-B4-2 below and the choices of response include: *'never or only rarely true of me'*, *'occasionally true of me'*, *'sometimes true of me'*, *'often true of me'*, *'always or almost always true of me'*, *and 'not possible to give a definite answer'*.

Table T4-B4-2: Items measuring teacher's reflective thinking and practice

Name of factor	Item	Content of the item
Habitual action	F1-1	When I am conducting teaching activities, I can perform my job with attention on other things at the same time.
	F1-2	I repeat some classroom duties so many times that I tend to do them without conscious thought.
	F1-3	I am so used to teaching routines that I can do them without conscious thought.
Thoughtful application	F2-1	When performing my teaching duties, I am consciously guided by my knowledge on various educational issues.
	F2-2	Discussing with other teachers helps me to apply educational knowledge into practice.
	F2-3	I use the educational knowledge that I have learned to interpret what is happening in the classroom.
Critical reflection	F3-1	When I solve a teaching problem, I consciously pay attention to the process.
	F3-2	I like to review what I have been doing for my pupils and (re)consider its efficacy.
	F3-3	I focus my attention on reviewing the possible clues to solving the specific teaching problem(s) that I have encountered.
	F3-4	To tackle a teaching problem, I ask myself about the features that I noticed when I recognised it as a problem.
Premise self-reflection	F4-1	I come up with a solution to a teaching problem after I have found the fault(s) in my interpretation of the problem.
	F4-2	I ask myself if I could have misinterpreted some incidents that I have used as evidence for making pedagogical decisions or judgements.
	F4-3	When tackling difficult problems about teaching, I make a conscious effort to find distortions in my reasoning or narrowness in my attitude.
	F4-4	Improper pedagogical decisions or judgements made by me tend to be caused by the lack of re-examination of my beliefs or assumptions about good teaching practice.

It was expected that:

- teachers in upper primary would have a more frequent use of 'thoughtful application', 'critical reflection' and 'premise self-reflection' than teachers in lower primary, as their pupils are more mature to give them formal and informal feedback, and

- in contrast, teachers in lower primary would have a more frequent use of 'habitual action' than teachers in upper primary, as the subject content for young children is relatively easier.

Teacher development: teachers' learning style

In a classroom situation, the teacher and the pupils interact with each other. Learning should not be restricted to the pupils in class, but also applies to teachers. A teacher's preferred learning style is a factor affecting his/her practice and professional development. So, this thesis has incorporated investigations on how teachers learn in terms of their own learning style. The measures concerning learning style were based on experiential learning theory proposed by Kolb. A review of literature about the theory will be reported in Chapter 5. The Learning Style Inventory (LSI-1985) was administered in a teacher questionnaire in 1998/99. Teachers were asked to make responses to each of the 12 items on LSI with a given ranking of 4 to 1, that represented "most like you", "second like you", "third like you" and "least like you". For example:

I learn by:	feeling	Watching	thinking	doing
	____	____	____	____

In referring to the experiential learning theory, teachers' responses to each of the four columns have their own theoretical meaning. Responses in the first column refer to a "concrete experience" learning orientation. This is followed by the "reflective observation" learning orientation and "abstract conceptualisation" learning orientation, respectively. The last column refers to "active experimentation" learning orientation.

It was expected that:

- teachers in upper primary would have a higher rating on 'reflective observation' and 'abstract conceptualisation' than teachers in lower primary, and
- teachers in lower primary would have a more frequent use of 'concrete experience' and 'active experimentation' than teachers in upper primary, as the subject content for young children is relatively easier than the one for older children.

(4-3) Research design, sampling, data collection and data treatment

Research design

To explore the effectiveness of a group of pedagogical and instructional variables concerning the use of ICT, a set of multiple regression models will be formulated. The justification for using multiple regression is that problems in the real world are so complex that there might be many solutions. The search for the pedagogy leading to effective use of ICT to support classroom teaching and learning is a complicated issue because there are interactions between the effects of different pedagogical variables. For example, the previous chapter has reported interactions between pupil characteristics and computer usage factors. So, it would be more appropriate to treat this as a complex system. It is hoped that generic patterns of relationship between pedagogical variables may emerge through comparisons and synthesis of these multiple regression models.

Information concerning educational performance will be used as dependent variables and information concerning pedagogy and instruction will be used as independent variables. The data collection and data treatment of the former has been mentioned in Section 4-1 above. The sampling procedure of these performance indicators is to match the respective teacher questionnaire data. Therefore, it might be appropriate to further describe the teacher questionnaires below.

Descriptive statistics, correlation statistics, alpha statistics, t-test and ANOVA technique will be used in the initial analyses. They will allow us to get an updated picture of classroom practice, to find out possible associations between variables, to examine the internal consistency of measurement scales and to compare the differences between data groups.

Sampling and data collection of teacher questionnaires

Data relating to pedagogical and instructional variables are based on three questionnaires completed by practising primary school teachers. The first questionnaire was sent out to 740 classes for which 1996/97 value-added data was available. This was sent in autumn term 1997/98 and 250 completed questionnaires were received. The return rate was 34%. The second questionnaire was sent out to 125 teachers who had completed the first questionnaire in autumn term 1998/99. These samples are selected at random, with the exception of the selection of 30 schools that were actively involved in the development phase of the TTAICT project. A total of 64 completed questionnaires were received, making a return rate of 51%.

The third questionnaire was sent to 53 teachers who had answered the second questionnaire and 30 teachers who had not answered the second questionnaire but indicated in the first questionnaire that they would like to be contacted. The questionnaire was sent out in the spring term 1998/99 after initial phone contact with the potential respondents. A total of 74 completed questionnaires were received, making a return rate of 89%. The major aims of this questionnaire were to repeat some of the key items of the first and the second questionnaire, which included information about their use of ICT to support the curriculum, teachers' IT skills/experience and their inclination towards the use of ICT. The rationale for this was to make data collected from the repeated sections comparable. The third questionnaire also collected additional information about teachers' learning styles, teaching practice and perceived challenges concerning the use of ICT in the classroom. For those who had returned the second questionnaire, the content of the third questionnaire was tailored in order not to repeat information that was collected in the second questionnaire.

The fourth questionnaire was sent to 197 teachers who had answered the first questionnaire and were still working as primary teachers by the summer term 1998/99, during which the teacher questionnaire was sent out. A total of 117 completed questionnaires were received, making a return rate of 59%. The major aims of the questionnaire were to seek permission for using PIPS data from teachers and to increase the sample size in respect of data collected about teaching practice and pedagogical preferences. There were additional phone contacts with another 30 teachers who were involved in the development phase of the TTAICT project to seek their permission to use the PIPS data for their class.

Generally speaking, it is obvious that the selected samples are not selected in a fully randomised way, but a mixture of convenient sampling (which is available to the TTAICT project or specifically for this PhD study) and random sampling. Due to the complexity of the sampling, attempts have been made to check the data collected against the data collected from national surveys. For instance, section 4-2-A2 shows us that the findings of these surveys are fairly consistent with findings of the national surveys in the academic year 1997/98 and 1998/99.

Data treatment of teacher questionnaires

Responses to the questionnaire items were coded numerically. The basic principle of the coding is to code the lowest value as "1", the next lowest value as "2" and so on. Taking into consideration the nature of the data, most of these items were found to be suitable to be treated as numerical data, while some remaining items were treated as text data. The rationale for the attempt to quantify data as "numeric" was to avoid confusion in data analysis, without significant loss in the meaning of the data.

Special attention was also given to the treatment of missing data in order to maintain a high quality database. The present study regards missing data as "system missing" and they were not used in the analysis. The rationale is to make the best use of the original responses with confidence and to avoid contamination of the quality of data resulting from speculation about missing values. This approach was different from the alternative, as adopted by the TTAICT project, which coded some missing data as a "0" value for data analysis. The decision was made after some statistical trials of the quality of the two sets of data. It was found that the current approach to data treatment consistently gave better correlation statistics in relation to other computer usage variables than the alternative approach did. As a result of this treatment of missing data, the alpha statistics of some composite variables in this study appeared to be lower than that of the alternative. However, in terms of the size of valid samples, the quality of the data seemed to be better than the former. Similarly, some items contain "not sure or impossible to give an answer" as one of the options on the questionnaire scale. The idea was to distinguish answers that were "sure" from the uncertain ones. After checking if there was any special pattern of occurrence of "not sure" answers, these data were treated as "missing data" and were dropped from the data analysis. The scale reported in Table T4-D3-1c is a typical example. The only exception was an item in which "not sure" was incorporated as one of the scale. The scale reported in Table T4-D4-2a is a typical example.

The original questionnaire items and the variable names can be found in Appendix 2-A and Appendix 2-B. Results of descriptive statistics are reported in the sections below. Some of the items in the first questionnaire were repeated in the second questionnaire in order to collect current information during the academic year 1997/98 and 1998/99.

(4-4) The results of initial statistical analyses

This section will report the results of initial statistical analyses, which include results of descriptive statistics, correlation statistics and t-tests. It aims at providing an updated picture about pedagogical and instructional practice in UK primary classrooms during the period of the PhD study. The sequence of presentation of variables will follow the sequence of pedagogical variables in section 4-2 because the variables in both sections are based on the "model of effective curricular teaching and learning supported by computers or other types of ICT" proposed in Chapter 2. All the statistical tests are in two-tailed tests. The letter "N" is used to stand for the sample size.

(4-4-A) Teaching tasks before the learning process

(4-4-A1) Knowing pupil characteristics and their ICT needs

Age/year group and number of pupils

Table T4-D1-1a: Age/year group of the selected samples [in %]

	Nurs.	Rec	Rec/Y1	Y1	Y1/2	Y2	Y2/3	Y3	Y3/4	Y4	Y4/5	Y5	Y5/6	Y6	
97/98	.8	29.1	4.0	3.6	2.4	22.3	.8	2.0	3.2	25.1	2.4	1.6	1.2	1.2	N=247
98/99	.8	36.2	.8	7.9	3.9	19.7	.8	3.9	1.6	12.6	.8	2.4	4.7	3.9	N=127

The survey item concerning the teachers' year group is fairly useful in describing the distribution of data in terms of pupils' age/year group. Details of the collected data are presented in Table T4-D1-1a above. The results of correlation statistics showed that there was a strong association between the teaching year group reported by the teacher in both academic years. The Pearson correlation statistic (r) was found to be .90, with N=120. The results of t-test showed that there was no statistical difference between the means of the teaching year groups reported in the two academic years, at $p < .05$ level. So, the assumptions about the unreliability of the sampling or data collection were rejected.

Throughout the thesis, there are investigations into the age/year group effects. The results will be reported in later sections, when other factors affecting the specific pedagogical variable are also taken into consideration. Nevertheless, a summary of the findings concerning age/year group will be presented in section 4-6.

Table T4-D1-1b: **The results of paired t-tests comparing the number of pupils in each level of primary education**

	Level 1 (N)	Level 2 (N)	Level 3 (N)	Level 2 & 3 (N)
1997/98 data	28.34 (35)	28.86 (14)	30.39 (18)	29.72 (32)
1998/99 data	28.31 (35)	28.79 (14)	28.89 (18)	28.84 (32)
Result of t-test	p = .98 (35)	p = .94 (14)	p = . 12 (18)	p = .20 (32)

Keys/remark: *N* refers to the sample size, ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above, ***Level 2 & 3*** refers to Year 2 and above.

A series of paired t-tests were carried out to examine the number of pupils in each level of primary education between data collected in the two academic years. No significant difference was found in each level of primary education. The details of the results are reported in Table T4-D1-1b. So, the assumptions about the unreliability of the sampling or data collection could be rejected. The results mean that there were no statistical evidence suggesting the non-comparability between data collected in these two years. This gives statistical support for making comparisons between data collected in these two years for various purposes, for instance, to show the trends or movements concerning the use of ICT.

Table T4-D1-1c: Average number of pupils in each level of primary education

	Samples (N)	No. of pupils (mean)	S.D.
Level 1	98	27.69	5.51
Level 2	68	29.34	3.89
Level 3	76	29.86	4.76

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

In both academic years, the average number of pupils in class was 29, with a minimum of 13 or 14. The maximum number was 54 and 40. The Table T4-D1-1c above reports the number of pupils at different levels of primary in 1997/98. One-way ANOVA suggested that there was a significant difference in the respective mean number of pupils between the three levels of primary education in 1997/98, at $p < 0.01$ level. It seemed that there were fewer pupils in level 1 than the other two levels in primary. Unfortunately, the relationship could not be confirmed from carrying out similar analysis with 1998/99 data because there were not enough pupils in each statistical condition.

There was a negative relationship between the number of pupils and pupils' opportunity to have a turn on the computer, at $p < .05$ level and N=241. The Pearson correlation statistic (r) is -.16. No significant relationship between the class size and the teacher's inclination towards using computers was found, at $p < .05$ level. So, the expectation that teachers of small-sized classes welcomed computers was not supported. However, there was also a positive relationship between the number of pupils in 1997/98 and the perception of workload, with $p < .05$ and N=101. The Pearson correlation statistic (r) was 24. No significant relationship was found between the number of pupils and the number of computers available or the hardware and software add-ons. This gives us a picture that in large classes, the teacher's workload for using computers is increased and the opportunity for pupils to have a turn on the computer is reduced, and vice versa.

Number of pupils on the special educational needs register at stage 3-5

The table below reported the number of SEN at different levels of primary in 1997/98. One-way ANOVA suggested that there was a significant difference in the respective mean number of SEN between the three levels of primary education in 1997/98, with $p < 0.01$ level (one-tail). The data suggested that there were more SEN children in upper primary than in lower primary. Unfortunately, the relationship could not be confirmed from carrying out similar analysis with 1998/99 data because there were insufficient numbers in each statistical condition.

Table T4-D1-1d: Average number of SEN in each level of primary education

	Samples (N)	No. of SEN (mean)	S.D.
Level 1	99	.77	1.45
Level 2	69	1.94	2.42
Level 3	78	2.45	2.78

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

The results of correlation tests with the 1997/98 data did not show any significant relationship between the number of SEN and any of the measures of learning attainment or progress. No significant relationship was found between the number of SEN and the provision of equipment or the number of hardware and software add-ons, with $p < .05$ and N= 250. A negative association was found between the number of special educational needs children in class and specifying the use of ICT in the teacher's weekly plan, with $p < .05$ and N=250. The Pearson correlation statistic (r) was found to be - .13. The implication was that some teachers of those classes with more SEN children avoid the use ICT in their weekly plan.

(4-4-A2) Provision of ICT equipment and resource allocation

Table T4-D1-2a: Descriptions of the 3 measures of equipment provision

Variable	Description of the measurement scale
Cncom	Number of computers available for the class
Cperi	Number of computer hardware and software add-ons
Cprov	The composite measure of provision of various ICT equipment

Information about the provision of equipment was collected by the questionnaire carried out in the academic year 1997/98. There were three main focuses concerning the provision of equipment. A description of each of the measures can be found in Table T4-D1-2a above.

Table T4-D1-2b: Descriptive statistics of the 3 measures of equipment provision

Variable	N	Mean	S.E.	S.D.	Minimum	Maximum
Cncom	251	2.18	.14	2.21	.00	20.00
cperi	251	7.64	.68	10.78	.00	76.00
cprov	251	9.02	.24	3.81	.14	17.14

Descriptive statistics of the 3 measures of equipment provision are reported in Table T4-D1-2b above. The results of descriptive statistics show that on average there were two computers available for the class. However, the variation between the maximum and the minimum number was found to be large. Out of 251 classes, it was reported that one of the classes did not have any computers and one of the classes has 20 computers available. It was found that 90% of the classes reported that there were around 0.5 to 3 computers available.

Table T4-D1-2c: Percentage of hardware/software add-ons

Hardware/Software add-ons	Overall [in %]
Are connected to a printer	84.76
Have a CD Rom	33.43
Have a hard disc drive	56.10
Are connected to the internet	4.57
Have ILS software installed	4.29

It was also reported that 3.5% of the classes did not have any computer hardware and software add-ons, as specified in section 4-2-A2 above. So, on average, the majority of the classes would have at least one of these add-ons. To be more specific, Table T4-D1-2c reports the percentage of each type of hardware and software add-ons. About 85% of the computers were attached to a printer, which seemed to be a symbol of equipment-rich status. As only 33% of the computer had a CD-ROM facility, it would be reasonable for us to speculate that at least 67% of the machines were not good enough to run most of the multimedia software programs. If this is true, the functionality of the equipment was still better than that of the national average, which reported that 26.9% of the computers had got multimedia facilities in academic year 1997/98 (see Appendix 8-A for further details).

There was also an attempt to compare the average number of pupils per computer in the teacher survey 1997/98 with that of the national survey of ICT in schools carried out by the government. It was found that the average number of pupils per computer in the teacher survey 1997/98 was 19.7. Although the figure was slightly lower than the national average, which was 17.6, it was within the 95% confidence limit of the national average. Therefore, we can say that the data sample of the survey 1997 was not significantly different from that of the national survey.

Table T4-D1-2d: The results of ANOVA (one-tailed) examining the difference in equipment provision between different levels of primary education

Names of var.	Pupils' level in primary education	Sample size	Mean	ANOVA Sig.
cncom	Level 1	99	1.93	.043*
	Level 2	70	2.02	
	Level 3	78	2.63	
cperi	Level 1	99	6.76	.099
	Level 2	70	6.93	
	Level 3	78	9.50	
cprov	Level 1	99	8.19	.002**
	Level 2	70	8.96	
	Level 3	78	10.08	

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

The results of ANOVA further showed that there was significant difference in the number of computers between pupils in different levels of primary education, at $p < .05$ level (one-tailed). Pupils in lower primary had fewer computers available for use, while pupils in upper primary had more computers available. There was no significant difference in hardware and software add-ons between different levels of primary education, at $p < .05$ level (one-tailed). The difference in the overall provision of ICT equipment was statistically significant at $p < 0.01$ level (one-tailed). The overall provision of ICT equipment for pupils in lower primary was not as good as the overall provision for pupils in upper primary. Details of the mean statistics and the significance value of ANOVA procedures are presented in Table T4-D1-2d. The results support the expectation that children in upper primary needed more computers and had better equipment provision than those in lower primary. However, the results did not support the expectation that more hardware and software add-ons were needed for upper primary than in lower primary. It means that better equipment was needed in both upper primary and lower primary levels because many applications required computers with multimedia facilities and supporting peripherals.

Table T4-D1-2e: Number of internet access points

Var. name	For whom	N	No access points	One access points	Two access points	4 to 23 access points
inet_p	teacher	67	43	46	5	6
inet_t	pupils	67	34	50	12	4

Keys: ***inet_p*** refers to the number of internet access points available for pupils, ***inet_t*** refers to the number of internet access points available for teachers.

Two items in the 1998/99 data concerned updated information on the number of internet access points available for use by both teachers and pupils in that academic year. Among the 67 teacher respondents, about 95% of them had fewer than three internet access points. The maximum number of internet access points available was 23. About 57% of the respondents reported that there were internet access points available for pupils to use. About two third of the teacher respondents reported that there were internet access points available for teachers to use. The details can be found in Table T4-D1-2e above.

The next issue is to compare the above figures with those of the national surveys. The DfEE report (see Table T4-B1-2a in section 4-2-A2 or Appendix 8-A) showed that 62% of primary schools had access to the internet in March 1999. The data reported in Table T4-D1-2e was collected from a teacher questionnaire at the end of February in 1999. It would be reasonably accurate to say that they were fairly close to the national average. Further data analysis also indicated that teachers and pupils often shared the same equipment. The correlation statistic between the two variables was highly significant, with an association size of 0.98 at $p < .001$ level and $N = 67$. The results of ANOVA did not find a significant difference in the mean number of internet access points available for use by teachers or by pupils between different levels of primary education, at $p < .05$ level (two-tailed).

(4-4-A3) Instructional setting, planning and decision-making

In 1997/98, 12.7% of the respondents reported that ICT was specified in their weekly planning. The figure recorded in 1998/99 was 17.9%. In the t-test results, no significant difference was found between the respective means of the two academic years, at $p <.05$ with N=77. Instead, a significant positive correlation was found between responses in both years. The Pearson correlation statistic (r) was 0.42, at $p < .01$ level with N=77. Furthermore, 41% of the respondents reported that they planned specific activities to support the computer programs that they used in 1997/98. The reported percentage of the same item in 1998/99 was found to be 48%. No significant difference between the two means was found by t-test at $p < .05$ level with N=74. A significant positive correlation was found between responses in both years. The Pearson correlation statistic (r) was 0.38, at $p < .01$ level with N=74.

The results of the t-tests also showed that there was a significant increase in the planning of specific computer activities for pupils with special needs from 1997/98 to 1998/98, at $p < .05$ level and N=76. There was also a significant increase in the adaptation of the use of programs to suit those with special needs from 1997/98 to 1998/98, at $p < .05$ and N=76. In both academic years, a significant correlation was found between the planning of specific computer activities for pupils with special needs and the adaptation of the use of programs to suit those with special needs, at $p < .01$ level with N = 77 and at $p < .05$ level with N = 77, respectively. The Pearson correlation statistic (r) were found to be 0.34, and 0.23, respectively.

Table T4-D1-2a: **The results of one-way ANOVA, with the average of the selected variables concerning instructional setting, planning and decision-making in 1997/98**

Pupils' level in primary education	**apit97 (N)**	**apso97 (N)**	**asac97 (N)**	**asad97 (N)**
Level 1	.89 (99)	.33 (99)	.31 (99)	.34 (99)
Level 2	.81 (70)	.41 (70)	.47 (70)	.37 (70)
Level 3	.79 (78)	.51 (78)	.49 (78)	.53 (78)
ANOVA results	p = .199	p = .055	p = .033	p = .037

Keys/remark: ***apit*** refers to specify ICT in weekly plan, ***apso*** refers to plan specific activities to support computer programs, ***asac*** refers to plan specific computer activities for SEN, ***asad*** refers to adapting the use of programs to suit SEN. ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above. The "No" responses was coded as "0" and the "Yes" responses was coded as "1".

One way ANOVA showed that in 1997/98 teachers working in lower primary levels spent less time planning specific computer activities for pupils with special needs than teachers in upper primary. And it was less likely for teachers in lower primary to adapt the use of programs to suit pupils with special needs than teachers in upper primary levels. Details of the means of each level of primary education and the ANOVA results of the corresponding items are reported in Table T4-D1-2a, with the "No" responses coded as "0" and the "Yes" responses coded as "1".

Section 4-4-A1 reported that a higher number of registered special needs children was found in upper primary than in lower primary in 1997/98. The results of one-way ANOVA statistics also found a significant difference in the planning of specific computer activities for pupils with special needs and the adaptation of the use of programs to suit those with special needs, with $p < .05$. It would mean the higher the level of primary education, the teacher was more likely to plan specific computer activities for pupils with special needs and the teacher was more likely to adapt the use of programs to suit those with special needs. The results might imply that the discrepancy in academic attainment between children with special educational needs and that of their peers increases as they get older. Further details of the statistics are also reported in Table T4-D1-2a. However, none of the two identified differences between lower and upper primary was found to be statistically significant in the ANOVA of 1998/99 data. The two identified relationships found in 1997/98 were not confirmed. No significant difference was found between the lower primary and the upper primary in relation to:

- the specification of ICT in weekly plan, or
- the incorporation of specific activities to support any computer programs in teacher's plan

(4-4-B) The practice of using ICT for Teaching / Instruction

(4-4-B1) Usage of ICT: frequency, intensity, duration and IT skills/experience

Extent of computer usage: frequency, intensity and duration of computer use

Table T4-D2-1a: Responses about computer usage frequency and intensity

Variable name	Sample size (N)	Very/less infrequently	Several times a month	Several times a week	Every day or daily
ccom97	241	3.3%	7.5%	28.2%	61.0%
ccom98	128	2.3%	12.5%	26.6%	58.6%
pcom97	246	13.4%	51.2%	30.1%	5.3%
pcom98	128	7.0%	46.1%	43.0%	3.9%

Keys: *ccom* refers to the frequency of class usage of computers, *pcom* refers to the intensity of pupil computer usage (i.e. opportunity for a typical pupil in class to have a turn on the computer).

It might be worthwhile to note that the content of the three questionnaire items about computer usage frequency, intensity and duration are listed in Section 4-2-B1, Table T4-B2-1a. The details of teachers' responses to the usage frequency and intensity can be found in Table T4-D2-1a.

In both academic years (1997/98 and 1998/99), primary classes used computers fairly frequently. On average, the frequency of class usage was more than 'several times a week', but less than 'every day'. Correlation statistics also showed that there were significant associations between each of the three pairs of variables (data of 1997/98 and 1998/99), range from .40 to .56, at $p < 0.01$ level with $N = 108$ to 113. The results of paired a t-test showed that there was no significant difference between the frequency of class usage in the two academic years, at $p < .05$ level with $N = 113$.

In the academic year 1997/98, when computers were used in class on a school day, it often happened that not all pupils in a class had a turn. Pupils had to wait for their turns. More than half of the primary classes reported that a typical pupil had several turns on the computer per month. The situation had slightly improved in 1998/99. On average, in both academic years, the opportunity for a typical pupil to have a turn on the computer was more than 'several times a month', but less than 'several times a week'.

Table T4-D2-1b: Responses about duration of computer use

Variable name	**Sample size (N)**	**Mean (in mins.)**	**Standard Error**	**Minimum (in mins.)**	**Maximum (in mins.)**
ptim97	233	27.81	1.31	.00	120.00
ptim98	122	33.50	2.54	5.00	150.00

Key: *ptim* refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week).

The t-test results showed that the mean statistics of the number of turns that a pupil had on the computer in 1998/99 was significantly higher than in 1997/98, at $p < .01$ level with $N = 117$. That would imply that pupils in primary classes had more opportunity to use computers in the academic year 1998/99 than in 1997/98. The t-test results also showed that the duration of time that a typical child spent on the computer during an average week in 1998/99 was significantly higher than in 1997/98, at $p < .05$ level with $N = 108$. The mean statistic for the former was 34 minutes, while the mean statistic for the latter was 28 minutes. The standard errors of the means were

2.54 and 1.31, respectively. The details about the duration of usage can be found in Table T4-D2-1b.

So far, the results concerning extent of computer usage gave a picture that the increase in the extent of usage from 1997/98 to 1998/99 was restricted to increase at pupil level, rather than at teacher/class level. It might be true that an increase in equipment provision, as suggested by the government's national survey (see Appendix 9-A and 9-B for further details), only increased the opportunity and the amount of time for pupils to use the computers. At that time, no significant change was brought to teacher's pedagogy concerning their use for pupil learning.

Table T4-D2-1c: **The results of one-way ANOVA of variables concerning frequency, intensity and duration of computer use in 1997/98 and 1998/99**

	Ccom97 (average)	**N**	**S.D.**	**ccom98 (average)**	**N**	**S.D.**
Level 1	3.55	96	.74	3.61	61	.59
Level 2	3.38	69	.81	3.16	32	1.05
Level 3	3.41	71	.81	3.32	31	.83
ANOVA	p = .297			p = .000		
	Pcom97 (average)	**N**	**S.D.**	**pcom98 (average)**	**N**	**S.D.**
Level 1	2.58	98	.75	2.62	61	.55
Level 2	2.10	70	.68	2.16	32	.85
Level 3	2.04	73	.68	2.29	31	.59
ANOVA	p = .000			p = .027		
	ptim97 (average)	**N**	**S.D.**	**ptim98 (average)**	**N**	**S.D.**
Level 1	25.18	91	17.89	27.42	61	17.94
Level 2	21.59	64	10.95	28.36	29	26.67
Level 3	36.11	74	25.50	47.32	28	37.02
ANOVA	p = .003			p = .003		

Keys/remark: *N* refers to the sample size, ***ccom*** refers to the frequency of class usage of computers, ***pcom*** refers to the intensity of pupil computer usage (i.e. opportunity for a typical pupil in class to have a turn on the computer), ***ptim*** refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week). ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

The results of ANOVA showed that there was no significant difference between the average frequency of using computers between classes at different levels of primary education in 1997/98, at $p < .05$ level. However, a significant difference was found in 1998/99, at $p < 0.01$ level. So, the expectation that lower primary classes used computers more frequently was weakly supported with caution. Further confirmation is needed. As the mean concerning the frequency of class usage in level 1 seemed to be higher than the other year groups, the result suggested that the frequency of using computers in early year classes was particularly high.

The results of ANOVA also showed that there were significant differences in the opportunity for a pupil to have a turn on the computer as well as the duration of using computers between different levels of primary education, both at $p < .01$ level. The pattern was found in both academic years. The higher the level of primary education, the less opportunity for a typical pupil to have a turn on the computer, and the longer the duration of time spent on the computer, and vice versa. So, the expected discrepancy, as described in section 4-2-A1 and section 4-2-B1, in the pattern of usage between lower and upper primary education was supported. The details can be found in Table T4-D2-1c.

Teachers' IT knowledge/skills and pupils' experience in using ICT at home

Table T4-D2-1d: Teachers' estimation on the percentage of pupils who use a computer at home (in different primary education levels)

Variable	**Content of the questionnaire item/ scale**	**Level 1**	**Level 2**	**Level 3**
it_psk97	...estimate the percentage of pupils in your class who use a computer at home. (___%)	21%	28%	37%

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

A questionnaire item about pupils' computer experience was asked in the survey administered in 1997/98. The content of the item is presented in section 4-2-B1.

Among the 205 respondents, an average of 28% of the pupils in their class used a computer at home. The results of one-way ANOVA showed that there was a significant difference in the estimated percentage between different year groups, at $p < 0.01$ level with N=200. It showed that a higher percentage of upper primary pupils used a computer at home than that of lower primary pupils. Only 21% of pupils at level 1 used a computer at home. The recorded percentage of pupils at level 2 was 28% and that of pupils at level 3 was 37%. So, the expected pattern of relationships in section 4-2-B1 was supported by the results. These figures and the questionnaire item is reported in Table T4-D2-1d.

Table T4-D2-1e: Internal consistency of the scales measuring teachers' IT skills/experience

Variable	Content of the questionnaire item/ scale	N	Alpha
itsk_b	The average of 4 items on teachers' basic IT skills	85	.92
itsk_w	The average of 4 items on teachers' word-processing IT skills	85	.93
itsk_s	The average of 4 items on teachers' spreadsheet IT skills	85	.87
itsk_d	The average of 4 items on teachers' database IT skills	85	.91
itsk_I	The average of 4 items on teachers' internet IT skills	85	.89
it_tsk98	***The average of all the items on teachers' IT skills (20 items)***	*85*	*.96*

In the 1998/99 questionnaire, there were 20 items asking about teachers' IT skills, as listed in section 4-2-B1. The alpha statistic showed that the 20 items were very good to formulate as an overall measurement scale, with five sub-scales. The overall alpha statistic was found to be 0.96, which means that the overall scale has a very high internal consistency. Furthermore, each of the five sub-scales also had high internal consistency. The details of these scales and their alpha statistics are presented in Table

T4-D2-1e. The results give good grounds for using these measures for further analysis in later sections.

Table T4-D2-1f: The results of one-way ANOVA (2-tailed) examining the difference in IT skills between teachers of different primary levels

Pupil level in primary education	Itsk_b	itsk_w	itsk_s	itsk_d	itsk_i	itskil
ANOVA result (sig.)	p = .011	p = .000	p = .003	p = .004	p = .044	p = .001
N in level 1, 2 & 3	39,19,20	39,19,20	39,19,20	39,19,20	39,19,20	39,19,20

Keys/remark: *N* refers to the number of teachers, ***itsk_b*** refers to basic IT skills, ***itsk_w*** refers to word-processing skills, ***itsk_s*** refers to spreadsheet IT skills, ***itsk_d*** refers to database IT skills, ***itsk_i*** refers to internet IT skills, ***itskil*** refers to overall IT skills. ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

In the analysis, there was an investigation of the difference in IT skills/experience between teachers of the three primary levels mentioned in the above text. The results of ANOVA statistics were reported in Table T4-D2-1f. It seemed that teachers in upper primary had better IT skills/experience than teachers in lower primary, at $p < .05$ level (2-tailed). Unfortunately, as the sample size of two of the statistical groups was not large enough, the results did not give us strong statistical confidence to draw a firm conclusion. So, an attempt was made to combine these two groups together for another statistical examination.

Table T4-D2-1g: The results of one-way ANOVA (1-tailed) examining the difference in IT skills/experience between two groups of teachers (below year 2 and other primary years)

Pupil level in primary education	itsk_b	Itsk_w	itsk_s	itsk_d	itsk_i	itskil
ANOVA results	p = .002	p = .000	p = .006	p = .002	p = .050	p = .000
N in group 1 & 2	39,39	39,39	39,39	39,39	39,39	39,39

Keys: *N* refers to the number of teachers, ***itsk_b*** refers to basic IT skills, ***itsk_w*** refers to word-processing skills, ***itsk_s*** refers to spreadsheet IT skills, ***itsk_d*** refers to database IT skills, ***itsk_i*** refers to internet IT skills, ***itskil*** refers to overall IT skills.

Two groups were formed, which included respondents teaching below year 2 and respondents teaching year 2 and above. It happened that each of the groups contained 39 teachers. With the expectation that teachers in upper primary had better IT skills/experience than teachers in lower primary, a one-tailed ANOVA was done. The results were reported in Table T4-D2-1g. It seemed that teachers in upper primary levels had better IT skills/experience than teachers in lower primary levels, at $p < .05$ level with N=39 (1-tailed). The difference applied to each of the sub-types of IT skills/experience, which included basic IT skills, word-processing skills, spreadsheet skills, database processing skills and the overall IT skills. So, the expected differences were confirmed.

(4-4-B2) Quality and appropriateness of instruction: the use of computers for curricular teaching and learning

Table T4-D2-2a: Internal consistency (alpha statistics) of curriculum usage of computers

Variable name	Sample size (N)	Alpha	Content of the questionnaire item/scale
tcu_97	232	N.A.	1 questionnaire item i.e. (use computers)...to demonstrate something to the whole class.
tcu_98	83	N.A.	as above
pcu_97	249	.75	12 questionnaire items e.g. (use computers)...as a reward, extension work, extra support,...etc.
pcu_98	85	.70	as above
cu_97	250	.74	All the 13 questionnaire items (see tcu_97/98 and pcu_97/98 above)
cu_98	85	.68	as above

In the questionnaire for the academic year 1997/98 and 1998/99, 13 items are about teachers' usage of the computer to support the curriculum. Teachers were asked to rate their usage according to the scale: 'less than once a fortnight', 'once a fortnight', 'once a week', 'once a day' and 'more than once a day'. A list of all the items is presented in section 4-2-B2. The results of alpha statistics showed that the items had reasonable internal consistency as measurement scales. Details of the scales and the sub-scales can also be found in the Table T4-D2-2a below. When all the 13 items were combined to formulate a scale about the usage of ICT in supporting the curriculum, the alpha statistics for the 1997/98 and the 1998/99 data were 0.74 and 0.68, respectively. These 13 items could be sub-divided into two types: teacher usage and pupil usage. The former type of usage was referring to the first item of this set of

13 questionnaire items, and the latter type was based on the average of the remaining items. Details about the sub-scales can be found in Table T4-D2-2a.

Table T4-D2-2b: The results of correlation and t-test statistics (two-tailed) concerning curriculum usage of computers in 1997/98 and 1998/99

ID	Description of the item (1997/98 & 1998/99)	Corr.	T-test	N
1	To demonstrate something to the whole class	.64**	increased	73
2	For pupils to use at play time	.67**	not sig.	32
3	As a reward	.43*	not sig.	28
4	As extension work	.29*	not sig.	54
5	As extra support for some pupils	.55**	not sig.	54
6	For information retrieval	.49**	not sig.	36
7	For analysing patterns and interconnections	.39*	not sig.	26
8	To practice basic skills	.39**	not sig.	70
9	For word-processing	.41**	not sig.	63
10	For number work	.45**	not sig.	61
11	As part of free choice activities	.58**	not sig.	55
12	For pupils to use when they have finished classwork	.55**	not sig.	38
13	For major project work	.46**	not sig.	45
	The average of item 2-13 above	*.39***	*not sig.*	*77*

Keys/remark: *N* refers to the sample size. * refers to $p < .05$ and ** refers to $p < .01$.

In relation to each sub-type of curriculum usage of computers, the results of correlation statistics showed that there were significant positive associations between the data collected in 1997/98 and those collected in 1998/99, at $p < .05$ level with N = more than 28. The t-test (one-tailed) results showed that there was a significant increase in the use of computers to demonstrate something to the whole class, at $p < .01$ level with N = 73. The frequency of using computers for teacher's presentation increased significantly from 1997/98 to 1998/99, although the average usage frequency of both years was between 'less than once in a fortnight' and 'once in a fortnight'. The t-test results did not find any significant difference in each of the other sub-types of curriculum use of computers, at $p < .05$ level with N = more than 28. Further details of the correlation tests and t-tests results are reported in Table T4-D2-2b.

The present study also carried out an in-depth study of each sub-type of curriculum use of computers in 1997/98, in relation to the levels of primary education. The results of ANOVA (2-tailed) showed that pupils in upper primary levels, when compared with those in lower primary, tend to have a higher usage of computers for:

- pupils to use at playtime (at $p < .05$ level with N = 42, 40 and 58),
- information retrieval (at $p < .01$ level with N = 34, 50 and 65) [repeated in 1998/99], and
- word-processing (at $p < .01$ level with N = 70, 67 and 72) [repeated in 1998/99].

Furthermore, the results of ANOVA showed that pupils in lower primary levels, when compared with those in upper primary, tend to have a higher usage of computers:

- as extension work (at $p < .05$ level with N = 69, 57 and 60),
- to practice basic skills (at $p < .01$ level with N = 87, 66 and 65),
- for number work (at $p < .01$ level with N = 86, 59 and 63) [repeated in 1998/99],
- as part of free choice activities (at $p < .01$ level with N = 80, 54 and 46) [repeated in 1998/99], and

- for pupils to use when they have finished classwork (at $p < .01$ level with $N = 57$, 49 and 48) [repeated in 1998/99].

To confirm the findings above, ANOVA was carried out with the 1998/99 data. All the confirmed findings were marked with 'repeated in 1998/99' above. Having said that, the polarity of all the findings from 1997/98 data was repeated in the 1998/99 data. Therefore, it might be reasonable to conclude that pupils in different levels of primary education have different patterns of curriculum usage of computers. The results revealed that the computer activities for upper primary children were relatively academic and intellectually demanding. These might include the search for information from a CD-ROM, internet or other electronic resources, the engagement in writing or productions on a word-processor. Due to the open-ended nature of the activities, pupils in upper primary might forgo their playtime as the cost for continuation of their work on the computer. On the contrary, computer activities for lower primary children were relatively relaxing, which could be a mixture of academic work and enjoyment. Computer activities could be part of their free choice activities, and they could be used as a form of supplementary work to do when pupils had finished their formal class work. The academic activities for lower primary pupils to work on the computers would likely be close-ended, including number work and practising basic skills.

Table T4-D2-2c: Teachers' responses to items concerning two subject focuses in using computers

to focus on ICT skills development (Sample size =119)			
0-24% of the time	25-50% of the time	51-74% of the time	75-100% of the time
51%	23%	19%	6%

Explicitly to support subject teaching (i.e. all curriculum subjects except ICT) (Sample size =119)			
0-24% of the time	25-50% of the time	51-74% of the time	75-100% of the time
39%	33%	17%	11%

Teachers' responses to the two subject focuses of computer usage are summarised in Table T4-D2-2c. On average, teachers spent 25-50% of their time in both subject focuses. The two items were correlated with each other, at $p < .05$ level with N=119 (two-tailed test). The Pearson correlation statistic (r) was 0.41. The greater the extent of the use of ICT to focus on pupils' ICT skill development, the greater the extent of the use of ICT explicitly to support subject teaching, and vice versa. In the results of t-test, no significant difference was found between the two means, at $p < .05$ level with N = 119. This might imply that computers were used simultaneously for developing pupils' ICT skills and for supporting subject teaching.

Table T4-D2-2d: Correlation and paired t-tests (one-tailed) results between two subject focuses in using computers

Level in primary education	Descriptions about the level in year group	Sample size (N)	Correlation (sig.) (foc_it & foc_sb)	Mean & t-test (sig.) (foc_it & foc_sb)
Level 1	Below year 2	57	.54 ($p < .01$)	foc_it < foc_sb
Level 2	Year 2 and below Year 4	29	.36 ($p < .05$)	foc_it < foc_sb
Level 3	Year 4 and above	27	.19	foc_it < foc_sb
All levels	*All year groups*	*119*	*.41 (p < .01)*	*foc_it < foc_sb (p < .05)*

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above. ***Foc_it*** refers to using computers for developing pupils' IT skills, ***foc_sb*** refers to using computers for supporting subject teaching and learning.

The results concerning subject focus in using computers suggested that there was close alignment between the two focuses of usage in the primary curriculum. It was decided to investigate whether or not the extent of the association between the two variables remained the same among pupils of different year groups. T-tests and correlation statistics were computed for each of the three different primary levels. The number of pupils, the correlation statistics and the t-tests results are summarised in Table T4-D2-2d.

The two subject focuses were found to be associated with each other among pupils at level 1, at $p < .01$ level with N=57. The correlation statistic was found to be highly significant, with the association size of 0.54. For pupils at level 2, the association was found to be marginally significant, at $p < .05$ with N =29. The Pearson correlation statistic (r) was 0.36. No significant association between the two focuses was found among pupils at level 3, at $p < .05$ level with N = 27. In each level of primary education, the mean percentage of time spent on using computers for supporting subject teaching was greater than that for developing pupils' IT skills/experience. However, the results of t-tests failed to show that the difference in mean percentage of time spent on different subject focuses was statistically significant in any one of the primary levels, at $p < .05$ level with $N = 57$, 29 and 27, respectively.

When data for all primary levels were considered as a whole, the correlation between two subject focuses of using computers was found to be statistically significant, at $p < .01$ level with $N = 119$. The result of t-test (one-tailed) also confirmed that the percentage of using computers for supporting subject teaching was significantly higher than the respective percentage for developing pupil IT skills/experience. So, the results appeared to be a weak support for the expectation mentioned in section 4-2-B2, but further statistical evidence would be needed for confirmation in the future.

The results indicated that the higher the year group of the pupil, the lower the association between the two curricular focuses. A possible explanation for this phenomenon is that young children require ICT skills training before performing a specific subject-related task on the computer. In other words, it is possible that young children lack basic IT skills/experience to perform a learning task supported by ICT. They need training in the specific IT skills/experience to complete the learning task. Older children in primary education, however, can benefit from a lesson that is clearly designed for developing their IT skills/experience or, alternatively, designed for developing their subject knowledge. ICT skills training and subject knowledge acquisition do not have to be linked closely.

(4-4-B3) Additional instructional support: adult helpers in class

Table T4-D2-3: The ANOVA results of the average number of adult helpers in class

	Level 1 (N)	Level 2 (N)	Level 3 (N)	One way ANOVA
97/98	.98 (98)	.80 (69)	.74 (76)	$p < 0.01$
98/99	1.00 (36)	.85 (21)	.68 (22)	$p < 0.01$

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above, *N* refers to sample size.

In the teacher survey 1997/98, 84% of the respondents reported that at least one adult was regularly available to help the class. The figure went up to 88% in the teacher survey 1998/99. The results of correlation statistics indicated that the data concerning adult helpers collected in 1997/98 was positively related to those collected in 1998/99, at $p < .01$ level with $N = 73$. The Pearson correlation statistic (r) was 0.54. The results of a t-test indicated that the means of the two measures did not significantly differ from each other, at $p < .05$ level with $N = 73$. That would mean there was no significant change in the availability of adult helpers in class during the two academic years. The one-way ANOVA results also showed that there was a significant difference in the average number of adult helpers between pupils in different levels of primary education, at $p < .01$ level. In both academic years, it was found that pupils in upper primary education had fewer adult helpers in class, and vice versa. Details about the mean statistics and AVOVA results are summarised in Table T4-D2-3 above. This supports the expected pattern of relationship mentioned in section 4-2-B3.

(4-4-C) Perception of feedback about learning and instruction

(4-4-C1) Perceived effects concerning the use of computers for teaching and learning

Table T4-D3-1a: Data concerning perception of effects on pupils learning resulting from the use of computers

Var. name	Content of the questionnaire item	N
af_oac	...your perception about the change in pupils' academic achievement since autumn 1997, due to the use of computers to support subject teaching.	67
af_oat	...perception about the change in pupils' attitudes towards learning since autumn 1997, due to the use of computers to support subject teaching.	85

In a teacher questionnaire 1998/99, two questionnaire items were designed to focus on teachers' perception of the effects on pupils as a result of the use of computers to support subject teaching. The content of the two items is presented in Table T4-D3-1a and the responses are presented in Table T4-D3-1b. The first one focused *on the effect* of pupils' cognitive achievement and the second one focused on pupils' attitudes towards learning. In both items, about 50% of the teachers reflected that they had perceived an improvement and 46% of the teachers reflected that they had not perceived any difference in their pupils as a result of the use of computers. In both items, only one teacher respondent reflected that there was a decline in outcome, and both of them were teaching year 4.

The results of correlation statistics showed that the two measures were significantly associated with each other, at $p < .01$ with N=60. The Pearson correlation statistic (r) was 0.37. The results of t-test indicated that the mean of the two measures did not significantly differ from each other, at $p < .05$ level with N =60(two-tailed). This might imply that there were close alignments between the academic achievement of these pupils and their attitude towards learning, or between the teachers' perceptions of these two aspects. So, the expected relationship concerning this issue, as mentioned in section 4-2-C1, was rejected. The results of ANOVA indicated that there was no significant difference in the means of the two items between different primary education levels, at $p = .05$ level with N = 26, 20, 17 (two-tailed), and at $p = .05$ level with N = 36, 23, 21 (two-tailed), respectively. This would imply that teachers did not have a more positive perception of the effects resulting from the use of computers with older children than with younger children.

Table T4-D3-1b: Summary of teachers' responses to two questionnaire items concerning their perception of effects on pupils learning resulting from the use of computers

Variable (Valid N)	Improved	No difference	Declined	Not sure or impossible to give an answer
af_oac (N=67)	52%	46%	2%	Dropped from analysis, with no special pattern of missing was found.
af_oat (N=85)	53%	46%	1%	Dropped from analysis, with no special pattern of missing was found.

An item in the teacher questionnaire was focused on the effect of using ICT on teachers' workload. Its content and their responses are presented in Table T4-D3-1c. When coding these categories from 1 to 5, the mean was 2.33. The result means that teachers have perceived that the workload resulting from the use of computers had "increased" slightly from the academic year 1997/98 to 1998/99. The results of ANOVA show that there is a significant difference in the mean of the perceived workload resulting from the use of ICT between different levels of primary education, at $p < .01$ with $N = 51, 27$ and 25 (2-tailed). Teachers in upper primary had higher perceived workload resulting from the use of computers. One of the possible reasons for that was that the computer activities in upper primary were relatively academic and intellectually demanding, while computer activities in lower primary were a mixture of academic work and leisure, as discussed in section 4-4-B2.

Table T4-D3-1c: Summary of teachers' responses to a questionnaire item concerning their perception of effects on teachers' workload resulting from the use of computers

...how the use of ICT to support subject teaching (i.e. all curriculum subjects except ICT) affected the teacher's workload when compared with teaching without the use of ICT.					
Increased a lot	*Increased*	*No difference*	*Decreased*	*Decreased a lot*	*Not sure or impossible to give an answer e.g. not using ICT at all*
6%	55%	38%	1%	0%	Dropped from analysis, no special pattern of missing

(4-4-C2) Perceived challenges: favourable and unfavourable factors concerning the use of computers for teaching and learning

The results of the mean statistics indicated that on average teachers' perception of personal challenges, institutional and work-related challenges and practical challenges were between "okay" and "unfavourable"

As responses to the 18 items concerning challenges of using computers mentioned in section 4-2-C2, teachers were asked to choose between the following options, which include:

- very favourable to the use of ICT,
- favourable to the use of ICT,
- okay,
- unfavourable to the use of ICT,

- very unfavourable to the use of ICT, and
- not sure (try not to use this).

Table T4-D3-2: The mean statistics and standard error of the means of the scales concerning challenges in using ICT for teaching and learning

Var. name	**Descriptions of the group of challenges, including barriers and supports**	**Mean (SE)**	**N**
chl_f1	Personal challenges i.e. knowledge & skills about using ICT	3.06 (.72)	67
chl_f2	Psychological challenges i.e. personal interest, expectation and concerns	2.57 (.72)	67
chl_f3	Institutional and work-related challenges i.e. duties, workload and time available	3.42 (.78)	67
chl_f4	Practical challenges i.e. the need for reliable equipment, technical support and additional supports for pupils	3.17 (.75)	67
chl98	*Challenge in general (including all the items above)*	3.10 (.62)	67

The collected data were coded as 1 to 5, starting from the top to the bottom of the list, with responses for the last option treated as missing data. Then the data were analysed by hierarchical cluster analysis technique. The details of the analysis and measures of internal consistency will be reported in Chapter 5 section 5-2-2. The results suggested that these items could be classified into four major groups, as illustrated in Table T4-D3-2 above, and items in each of the groups had reasonable internal consistency. The results of mean statistics showed that the responses to psychological challenges were between "favourable" and "okay", while the mean statistics of the other three types of challenge were slightly beyond "okay" and heading toward "unfavourable". This might mean that the psychological challenges that teachers faced were not as great as the other three types of challenge. If this is true, simply encouraging teachers to use computers would not be an effective strategy to promote their use. Instead, effort needs to be put into non-psychological factors, such as providing teachers with training in IT knowledge and skills, reducing their work duties and workload, and providing technical, financial and human resource support.

The results of ANOVA showed that there was no significant difference in the first three groups of variables between different levels of primary education. The only significant difference between different levels of primary education was found in the fourth group of variables, at $p < 0.05$ level with N = 32, 18 and 20. It was found that the higher the primary education levels, the lower the practical challenge measure. In relation to the expectation mentioned in section 4-2-C2, the result was rather unexpected. However, it was consistent with the findings that upper primary classes had more computers available, more computer hardware/software add-ons, and better computer equipment provision than lower primary classes. With these practical advantages, teachers in upper primary perceived fewer practical challenges than those in lower primary.

(4-4-C3) Inclination towards using computers in the classroom

Table T4-D3-3a: The results of measurement of internal consistency (alpha statistics) concerning teachers' inclination towards using computers

Variable	N	Alpha	Composition of the scale
td_97	226	.76	Mean of 13 items about inclination towards the use of ICT in 1997/98
td_98	68	.74	Mean of 13 items about inclination towards the use of ICT in 1998/99

Thirteen items measuring the teacher's inclination towards using computers in the classroom were asked in a teacher questionnaire in the academic year 1997/98 and 1998/99, respectively. These items, and the choices given, were described in section 4-2-C3. The results of alpha statistics showed that these items had a fairly good consistency to act as a scale about teachers' inclination towards the use of ICT in the classroom. They were found to be 0.74 and 0.76, as reported in Table T4-D3-3a respectively. Further details about the scale validated in 1997/98 and 1998/99 are presented in Table T4-D3-3a.

Table T4-D3-3b: The results of correlation statistics between various measures of teachers' inclination towards using computers and the type of challenges perceived by teachers

	chl_f1	chl_f2	chl_f3	chl_f4	chl_98
td_97 &	-.35**	-.26*	-.45**	-.27*	-.40**
N=	69	69	69	69	69
td_98 &	-.60**	-.54**	-.56**	-.50**	-.66**
N=	74	74	74	74	74

Keys/remark: td_97 refers to inclination towards using computers in 1997/98, td_98 refers to inclination towards using computers in 1998/99, chl_f1 refers to personal challenges perceived by the teacher, chl_f2 refers to psychological challenges perceived by the teacher, chl_f3 refers to institutional and work-related challenges perceived by the teacher, chl_f4 refers to practical challenges perceived by the teacher, * refers to $p < .05$, ** refers to $p < .01$.

As teachers' inclination towards using computers was expected to have links with the extent of challenges perceived by them, a set of correlation statistics was computed. The results were reported in Table T4-D3-3b above. Generally speaking, teachers' inclination towards using computers was negatively related to the extent of challenges perceived by them, at $p < .05$ level. The results concerning the Pearson correlation statistic (r)s were found to be reasonably large. For example, The Pearson correlation statistic (r) between inclination towards using computers in 1998/99 and the extent of challenges perceived by them in the same academic year was as high as -0.66. So, the expected pattern of correlation was supported by the data.

Table T4-D3-3c: The results of correlation statistics and t-tests concerning teacher's inclination towards using computers for teaching and learning

ID	Content of the questionnaire item	Valid N	Corr.	Paired-T
1	My school has a plan to develop the use of ICT across the curriculum.	68	.36**	not sig.
2R	In my school, there is not enough information about published educational software.	69	.35**	not sig.
3	I think the educational use of ICT is cost-effective.	68	.40**	not sig.
4R	It is hard to include computer work in most sessions.	68	.33**	not sig.
5R	My pupils do not have adequate keyboard skills for using computers.	68	.32**	not sig.
6	Computers make me feel good about my teaching.	66	.30*	not sig.
7	I know that parents are generally positive about the educational use of computers.	67	.16	p < .05
8R	It is hard to monitor pupils' learning on computers.	69	.36**	not sig.
9R	I find that most software is not appropriate for the National Curriculum.	68	.34**	not sig.
10	I am keen on the educational use of ICT.	68	.30*	p < .05
11R	Most software is too complicated for my pupils to use.	68	.51**	not sig.
12R	It is difficult to plan follow-up work for computer activities.	69	.56**	not sig.
13R	For me, planning a computer-supported lesson is too time-consuming.	68	.32**	not sig.

Keys/remark: *N* refers to the number of teachers * refers to $p < .05$ and ** refers to $p < .01$.

Correlation tests and paired t-tests were performed to investigate the relationships between responses to each of the items administered in the two academic years. A summary of the results is presented in Table T4-D3-3c. Generally speaking, each pair of corresponding items of the two questionnaires was found to be significantly associated with each other, at $p < .05$ level, except the item concerning teachers' expectation of parents' attitude towards using computers (item 7 in Table T4-D3-3c). The Pearson correlation statistic (r) of the significant correlation statistics ranged from 0.30 to 0.56. The results of paired t-test showed that there was a significant increase in the mean statistic of item 7, at $p < .05$ level with $N = 67$. It went up from 3.8 in 1997/98 to 4.0 in 1998/99. This implies that a typical respondent's knowledge about parents' supportive attitude towards educational use of computers was in the mid-point between "unsure" and "agree" in 1997/98, but it was close to "agree" in 1998/99. The paired t-test results also indicated that there was a significant decrease in the mean of the item concerning agreement with the statement about teachers' intention to the use of ICT for educational purposes (item 10 in Table T4-D3-3c), at $p < .05$ level with $N = 68$. The typical response in 1997/98 was "agree", while the typical response in 1998/99 was between "unsure" and "agree". The pattern of relationship was rather unexpected. One of the possible explanations is that the perceived effects of using computers were not as good as the teacher's expectation. So, they were less keen on using it in the following academic year. Further investigation into this issue is needed.

Table T4-D3-3d: The results of ANOVA comparing the inclination towards using computers between the three levels of primary education

ID	Content of the questionnaire item in survey 1997/98	Mean L1(N)	Mean L2(N)	Mean L3(N)	ANOVA results
3	I think the educational use of ICT is cost-effective.	3.15 (96)	3.18 (68)	2.81 (75)	p < .05
11	Most software is too complicated for my pupils to use.	3.26 (97)	3.62 (69)	3.72 (75)	p < .01
ID	**Content of the questionnaire item in survey 1998/99**	**Level 1**	**Level 2**	**Level 3**	**ANOVA results**
6	Computers make me feel good about my teaching.	2.55 (31)	3.06 (18)	3.25 (20)	p< .05
11	Most software is too complicated for my pupils to use.	3.03 (31)	3.22 (18)	3.95 (20)	p < .01

Keys/remark: *L1* refers to below year 2, *L2* refers to Year 2 and below Year 4, *L3* refers to Year 4 and above, *N* refers to sample size. Mean value "1" typically refers to "strongly disagree", "2" typically refers to "disagree", "3" typically refers to "not sure", "4" typically refers to "agree", and "5" typically refers to "strongly agree".

The results found to be statistically significant in the ANOVA comparing the inclination towards using computers between the three levels of primary education are reported in Table T4-D3-3d above. It was found that there were significant differences between the three levels of primary education in the mean statistics of item number 3 and 11 in 1997/98 (at $p < .05$ and $p < .01$ level respectively), as well as differences in the mean statistics of item number 6 and 11 in 1998/99 (at $p < .05$ and $p < .01$ level respectively). In 1997/98, the level of agreement that teachers in level 3 had with the statement "I think the educational use of ICT is cost-effective" was significantly lower than teachers in the other two primary levels. In 1998/99, the level of agreement that teachers in upper primary had with the statement "computers make me feel good about my teaching" was higher than teachers in lower primary. In both academic years, teachers in upper primary were found to have stronger agreement with the statement "most software is too complicated for my pupils to use".

(4-4-D) Teachers' personal characteristics and professional development

(4-4-D1) Experience and Subject knowledge

Table T4-D4-1a: Descriptive statistics concerning teaching experience

Name	N	Minimum	Maximum	Mean	S.E.	S.D.
aax97	245	1 (yrs.)	44 (yrs.)	14.31	.55	8.62
aax98	44	2 (yrs.)	31 (yrs.)	15.91	1.13	7.48
aax98e	241	2 (yrs.)	45 (yrs.)	15.23	.56	8.62

Keys/remark: ***aax97, aax98 and aax98e*** refer to the teacher questionnaire item "How many years have you been a teacher, including this year?" ***S.E.*** refers to standard error of the mean and ***S.D.*** refers to standard deviation.

Table T4-D4-1a presents a set of variables concerning the respondents' teaching experience. Generally speaking, respondents in both academic years represented a wide spectrum of experience, ranging from 1 to 44 years of teaching experience in 1997/98 and from 2 to 31 yeas in 1998/99. The mean number of years of teaching experience was found to be 14.3 and 15.9, with the standard error of 0.55 and 1.13, respectively. To facilitate further analysis, the two variables were combined to function as a third variable, which indicated the amount of experience that a teacher had in the academic year 1998/99 with the assumption that the teacher was still working as a teacher by that time.

Table T4-D4-1b: **The average number of IT co-ordinators in each primary education level**

	Level 1 (N)	Level 2 (N)	Level 3 (N)
acit97	.051 (99)	.114 (70)	.244 (78)
acit98	.026 (38)	.210 (19)	.350 (20)

Keys/remark: ***Level 1*** refers to below year 2, ***Level 2*** refers to Year 2 and below Year 4, ***Level 3*** refers to Year 4 and above.

Among the 251 respondents in the 1997/98 survey, 12.7% of them were IT co-ordinators for the school. Among the 84 respondents in the 1998/99 survey, 17.9% of them were IT co-ordinators for the school. T-test statistics did not show a significant difference between the two means, at $p < .05$ level with N=77. The correlation between the responses to the survey over the two years was highly significant, at $p < .01$ level with N=77. The Pearson correlation statistic (r) was 0.79. This means that many IT co-ordinators in 1997/98 continued working as IT co-ordinators in 1998/99. The percentage of respondents who were English and Maths co-ordinators in 1998/99 was found to be 14.5% and 21%, respectively.

The results of one way ANOVA did not identify any significant difference in the number of English co-ordinators or in the number of Maths co-ordinators between different levels of primary education, both with $p < .05$ level. Instead, the results suggested that there were more IT co-ordinators in upper primary levels than in lower primary levels, with $p < .01$ level. Such a pattern consistently occurred in 1997/98 and 1998/99. So, the expected pattern of the relationship mentioned in section 4-2-D1 was supported. Details of the figures can be found in Table T4-D4-1b.

(4-4-D2) Teachers' interest, conceptual preferences and reflective practice

Personal interest in computers

Table T4-D4-2a: Teachers' responses to the survey item concerning their attitude towards computers.

	Please tick the appropriate box to show your attitude toward computers:				
	Strongly dislike them.	*Dislike them.*	*Not sure (try not to use this box)*	*Like them.*	*Strongly like them.*
All teachers N=72	*0%*	*10%*	*0%*	*65%*	*25%*
English co-ordinator N=8	*0%*	*13%*	*0%*	*63%*	*25%*
Maths co-ordinator N=11	*0%*	*9%*	*0%*	*82%*	*10%*
IT co-ordinator N=11	*0%*	*0%*	*0%*	*36%*	*64%*

An item in the survey 1998/99 was focused on teachers' personal attitudes towards computers. Its content and their responses are presented in Table T4-D4-2a above. When coding these categories as 1 to 5, the mean is 4.06. It means that teachers generally showed a positive attitude towards computers. On the other hand, it might be worthwhile to note that 10% of the respondents revealed a negative attitude towards computers. There is no significant difference in teachers' personal attitudes towards computers between teachers of different levels of primary education, at $p < .05$ level with N=31,18,19. The results also indicated that all the eleven IT co-ordinators in this study had a positive attitude towards computers, while English and Maths co-ordinators had a mix of positive and negative attitudes towards computers.

Pedagogical and instructional preferences

In Section 4-2-D2 above, we have discussed on the effects of teachers' beliefs, their conceptions of teaching or personal constructs on their teaching effectiveness. In this study, five measurement scales concerning teachers' pedagogical preference were formulated. It is hoped that the set of variables will enable us to explore and understand more about teachers' pedagogical decisions and thinking processes.

The names of the scales, their compositions and the alpha statistics are reported in Table T4-D4-2b below. The results of one-way ANOVA showed that there was no significant difference in pedagogical preference for supporting the use of ICT between different levels of primary education, at $p < .05$ level with $N = 36$, 17 and 18. So, the expected pattern of relationship was not supported.

Table T4-D4-2b: **The results of the internal consistency (alpha statistics) of the scales measuring teachers' pedagogical preference**

Variable	Preference of A to B (preference A vs. B)	Items [dropped out item(s)]	N	Alpha
g_p_ict	Pro-ICT (vs. anti-ICT) attitude	c_11r, c_27r, c_33r, c_61r [c_43r]	75	.80
g_p_pup	Pupil control (vs. teacher control)	c_12r, c_22r, c_28r, c_32r [c_10, c_51r]	75	.82
g_p_open	Open (vs. close) activities	c_02r, c_20r, c_42, c_70 [c_25]	75	.79
g_p_coll	Collaborative (vs. individual) work	c_03r, c_16r, c_29r, c_64r, [c_63]	75	.79
g_p_lang	Language (vs. Math)	c_04r, c_15, c_31r, c_50	75	.86

Remark: Further details about the measuring instrument and the measurement scales can be found in Section 4-2-D2. The components of the five measurement scales were supported by results of factor analysis to be reported in Chapter 5 section A2-2.

Professional development: teachers' reflective practice

The review of literature about the education and training of professionals in Chapter 5 has suggested that practitioners' reflection of their own practice is an important aspect of learning by experience. This applies to both novices and experts. To make a step forward, an instrument was constructed to measure primary teachers' reflection on their own practice. After administering the teacher questionnaire, the responses were coded according to the scale below:

- "0" for 'Never or only rarely true of me',
- "1" for 'occasionally true of me',
- "2" for 'sometimes true of me',
- "3" for 'often true of me',

- "4" for 'always or almost always true of me', and
- "missing value" for 'not possible to give a definite answer'.

As one of the major aims of the analyses (see chapter 5) was to build a confirmatory factor analysis (CFA) model for the theory, some of these items needed to be dropped. The item selection procedure began by examining the internal consistency of all the items in each of the four proposed factors. After dropping items that had a low inter-item correlation, the best set of 3 to 4 items were remained in each of the four proposed sub-scales. The results of confirmatory factor analysis, as reported in chapter 5, also confirmed that the measurement scale had a four-factor structure. The content of the final set of 14 items and the given choices are illustrated in section 4-2-D2 above, and further information abut the names, compositions, and the alpha statistics are presented in Table T4-D4-2c.

Table T4-D4-2c: Composition of the scales measuring reflection

Variable	**Descriptions**	**Items (see section 4-2-D2)**	**N**	**Alpha**
pr_ff1	Habitual action	F1-1, F1-2, F1-3	116	.63
pr_ff2	Thoughtful application	F2-1, F2-2, F2-3	117	.74
pr_ff3	Critical reflection	F3-1, F3-2, F3-3, F3-4	117	.73
pr_ff4	Premise self-reflection	F4-1, F4-2, F4-3, F4-4	115	.66
	Overall	*All items*		*.81*

The alpha statistics showed that the internal consistency between items on each scale seemed to be fairly acceptable, ranging from 0.63 to 0.74. Consideration was given to incorporating other items that were expected to be on the same scale in order to make further improvement to the alpha statistics. The cost for adopting this alternative would have been the loss of theoretical relations between the factors in the confirmatory factor analysis model. Therefore, it was decided not to include the dropped items in the scale and sub-scales.

The results of descriptive statistics are reported in Table T4-D4-2d. It showed that the appropriateness of using items in the 'thoughtful application' scale to describe the respondent teacher was between 'often true' and 'always or almost always'. The appropriateness of using items in each of the other three scales to describe the respondent teacher was between 'sometimes true' and 'often true'. The results of paired t-tests further showed that the difference between 'habitual action' and 'thoughtful application', and the difference between 'critical reflection' and 'premise self-reflection' were statistically significant, at $p < .01$ level. Furthermore, the difference between 'habitual action' and 'premise self-reflection' was also found to be statistically significant. This would imply that 'thoughtful application' was the most preferred thinking and action mode used by the respondent teachers. This would be followed by the use of the 'critical reflection' mode and the 'habitual action' mode. Among the four modes of thinking and action, The 'premise self-reflection' was the least preferred.

Table T4-D4-2d: Descriptive statistics of the scales measuring reflection

Variable	N	Minimum	Maximum	Mean	S.D.
pr_ff1	116	.00	4.00	2.33	.91
pr_ff2	117	.67	4.00	3.15	.70
pr_ff3	117	1.00	4.00	2.81	.69
pr_ff4	115	.25	3.75	2.18	.69

Keys: Refer to section 4-4-D2 for the coding of data, ***pr_ff1*** refers to the implementation of teaching practice as a habitual action or routine, ***pr_ff2*** refers to the implementation of teaching practice through thoughtful application, ***pr_ff3*** refers to the implementation of teaching practice through critical reflection, ***pr_ff4*** refers to the implementation of teaching practice through premise self-reflection.

The results of one-way ANOVA showed that there was no significant difference in the means of any one of the four measuring scales between teachers of different levels of primary education, at $p < .05$ level (two-tailed). So, none of the expected pattern of relationships was supported by the data.

Teacher development: teacher's learning style

The Learning Style Inventory (LSI-1985) was administered to 70 teachers in 1998/99. Eight measurement scales were formulated after items of the same theoretical orientation were combined together, however, only four of those will be used in this chapter. The results of descriptive statistics will be reported in Chapter 5 section 5-1-1-2-1. The details of the variable names, their compositions and the alpha statistics are presented in Table T4-D4-2e below. Generally speaking, the internal consistency between items within each of the scales was found to be reasonably high. This provides a good empirical basis for further investigation and analysis. The results of one-way ANOVA showed that there was no significant difference in the means of any one of the eight learning styles measuring scales between teachers of different levels of primary education, at $p < .05$ level with $N = 32$, 18 and 20. So, none of the expected pattern was supported by the collected data.

Table T4-D4-2e: Composition of the scales measuring teachers' learning style (an abstract from chapter 5)

Variable	Descriptions (Abbreviations)	Items	N	Alpha
ls_f	Concrete experience (CE)	Mean of 12 CE items	74	.78
ls_h	Reflective observation (RO)	Mean of 12 RO items	74	.85
ls_k	Abstract conceptualization (AC)	Mean of 12 AC items	74	.87
ls_o	Active experimentation (AE)	Mean of 12 AE items	74	.89

Research methodology & features of the collected data

What is the best pedagogical and instructional arrangement leading to the effective use of ICT to support teaching and learning?

Perhaps one the best answers for the question is "It depends...." because the question is so complex that it cannot be answered by a simple ideal answer. It is likely that there is more than one way of making the use of ICT effective for teaching and learning, and selection of teaching methods often depends on the type of learning outcome that we want to achieve. It means that a systematic investigation is needed, since the size of the database is quite large. And it would be too difficult and impractical to investigate every pair of linkages between variables. Having said that, two features of the existing database were identified:

1. It is possible to classify these variables as two types: outcome variables and pedagogical variables. The former ones are presented in Section 4-1 above and the latter ones are presented in Section 4-2 above.
2. Some data were collected on a longitudinal basis. That includes questionnaire items collected during the academic year 97/98 and 98/99.

To investigate the effectiveness of some pedagogical variables, the present data collection allows us to investigate the group of potential factors that make contributions to a specific type of learning outcome. In the following sections, a series of multiple regression models will be formulated. The sample size of the valid case is greatly limited by the technical difficulties met during the process of identifying and matching pedagogical data and learning performance data. Roughly speaking, the number of cases that was successfully matched for the 1997/98 database and for the 1998/99 database was 69 and 29, respectively.

In each model, a group of pedagogical variables is used as predictors for a specific type of learning outcome. The variable is selected by the "enter" method and the samples for analysis are selected by the "pairwise" procedure. The group of predictors may include pedagogical variables that are not strong enough to be significant independent predictors of learning outcome, but which are found to be making a contribution to the statistical model of prediction when working together with other pedagogical variables. The major reason for this is that the effects of one variable can interact with the effects of another variable. In other words, the whole is greater than the sum of the parts. It is therefore, more appropriate for us to look at the simultaneous effects of a group of factors, rather than look at the effects of a single factor. On the basis of this, the present study considers the simultaneous effects of pedagogical variables that are related to the use of ICT and pedagogical variables that are not directly related to the use of ICT. To promote effective teaching and learning, teachers have to consider the simultaneous work of various pedagogical variables. It is possible that the interaction effects of two positive factors could have a negative impact on teaching and learning!

Special attention was paid to the selection of pedagogical variables to be put in the statistical model of prediction. The first set of variables to be put in the statistical model contains all the pedagogical variables that are significantly correlated with the target learning outcome variable. The model was refined after dropping some variables that were not good enough to work simultaneously in the group. In several exceptional circumstances, variables not included in the first set were added because they contribute to the group of predictors. It was expected that there would be 2 to 6 predictors in the final prediction model.

The investigation is extended by the construction of a path model, in which links between variables are taken into consideration. The expected technical difficulty is that correlation statistics cannot differentiate the causal impact of one variable on another. The researcher makes an attempt to distinguish the cause from the effect using two-wave two-variable (2W2V) path modelling technique.

(4-5) Factors affecting the effectiveness of teaching and learning supported by ICT

This section will begin by investigation of some factors directly affecting the effectiveness of teaching and learning supported by ICT. It will be followed by exploration of the inter-relationships between some of the identified factors, with careful consideration of the cause-and-effect relationships. The results can be combined together and are used to validate the "model of effective curricular teaching and learning supported by computers or other types of ICT" presented in Chapter 2.

(4-5-1) Factors directly affecting the effectiveness of teaching and learning supported by ICT

The following sections will report the results of a series of multiple regression models. The data variables are mainly based on data collected in the academic year 1997/98. Some data variables from the 1998/99 database are also used, given that information on these variables is not available from the 1997/98 database. Missing data were excluded from the analysis on a "pairwise" basis. The identified factors were found to be statistically significant in affecting the dependent variables on a group basis, with $p < 0.05$ (two-tailed, F statistics of ANOVA test).

Nearly all of them were found to be statistically important in the model predicting the dependent variable, with $p < 0.05$ (two-tailed, t statistics of linear regression test). There are also several exceptions, which are marked with an "^". Each of these variables was not statistically strong enough to make independent contribution to the model (i.e. $0.05 < p < 0.10$), but it appeared to be making some contribution when working simultaneously together with other independent variables for the prediction. Variables that were found to be statistically weak in their importance in the model were dropped (i.e. $p > 0.10$). To indicate the direction of the relationship between the dependent variables and the predictors, a "[+]" or a "[-]" sign will be used to represent a "positive" or a "negative" relationship, respectively. Tests of co-linearity were also performed. These include tolerance statistics and variance inflation factor statistics. No co-linearity between independent variables was detected in these tests. The polarity and the effect size of each predictor will be reported in the Beta column of the respective table.

(4-5-1-1) Pedagogical variables affecting academic attainments

(4-5-1-1a) A multiple regression model predicting maths attainments

The results of ANOVA test in the multiple regression statistic model suggested that 47% of the variance in pupils' maths attainment in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the percentage of pupils in class who use a computer at home (it_psk) [+],
- teachers' inclination towards the use of ICT in the classroom (td_97) [+],
- the implementation of teaching practice as a habitual action or routine (pr_ff1) [-], and
- the adaptation of programs to make ICT suit those with special needs (asad97) [-].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Maths attainment	it_psk	.51	.000	205
(t_o_zma)	td_97	.35	.002	248
	pr_ff1	-.28	.014	116
	asad97	-.26	.024	251
R-square = .47 (N=68) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section.

(4-5-1-1b) A multiple regression model predicting reading attainments

The results of ANOVA test in the multiple regression statistic model suggested that 57% of the variance in pupils' reading attainment in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- teachers' inclination towards the use of ICT in the classroom (td_97) [+],
- the extent pf institutional and work-related challenges perceived by the teacher in relation to the classroom usage of ICT (chl_f3) [+],
- the percentage of pupils in class who use a computer at home (it_psk) [+], and
- teachers' learning with reflective observation mode of orientation (ls_ro) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Reading attainment	td_97	.49	.001	248
(t_o_zre)	chl_f3	.42	.004	74
	it_psk	.39	.003	205
	ls_ro	.27	.029	74
R-square = .57 (N=68) , the resullts of ANOVA sig. = .000				

Keys: *D.V.* refers to dependent variable, *I.V.* refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-1c) A multiple regression model predicting academic attainments (the average of maths and reading)

A regression model was constructed to predict the average attainment of maths and reading. The results suggested that 62% of the variance in pupils' academic attainment in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- teachers' inclination towards the use of ICT in the classroom (td_97) [+],
- the extent of institutional and work-related challenges perceived by the teacher in relation to the classroom usage of ICT (chl_f3) [+],
- the percentage of pupils in class who use a computer at home (it_psk) [+],
- the adaptation of programs to make ICT suit those with special needs (asad97) [-],
- the planning of specific activities to support any computer programs that the teacher use ^ (apso97) [+], and
- the specification of ICT in teachers' weekly planning ^ (apit97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Reading attainment (t_o_zaa)	td_97	.49	.001	248
	chl_f3	.40	.006	74
	it_psk	.39	.002	205
	asad97	-.28	.023	251
	apso97	.22	.075	251
	apit97	.21	.083	251
R-square = .62 (N=68) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-2) Pedagogical variables affecting academic learning gains

(4-5-1-2a) A multiple regression model predicting maths learning gains

In this study, concurrent value-added measures have provided us with the basis for making judgement about pupils' learning gains. The results of ANOVA test in the multiple regression statistic model suggested that 15% of the variance in pupils' standardised maths gain in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the adaptation of programs to make ICT suit those with special needs (asad97) [-], and
- teachers' inclination towards the use of ICT in the classroom (td_97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
maths gain	asad97	-.34	.005	251
(t_r_voma)	td_97	.26	.031	248
R-square = .15 (N=68) , the resullts of ANOVA sig. = .005				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-2b) A multiple regression model predicting reading learning gains

The results of ANOVA test in the multiple regression statistic model suggested that 39% of the variance in pupils' standardised reading gain in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- teachers' learning with reflective observation mode of orientation (ls_ro) [+],
- the adaptation of programs to make ICT suit those with special needs (asad97) [-],
- teachers' inclination towards the use of ICT in the classroom ^ (td_97) [+],
- the preference for teaching with ICT as opposed to without ICT ^ (p_ict) [-], and
- the number of pupils in the teaching group or class ^ (aanp97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
reading gain (t_r_vore)	ls_ro	.34	.031	74
	asad97	-.31	.047	251
	td_97	.30	.055	248
	p_ict	-.27	.078	75
	aanp97	.25	.091	246
R-square = .39 (N=68) , the resullts of ANOVA sig. = .008				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described *in the text of this section*

(4-5-1-2c) A multiple regression model predicting academic learning gains (the average of maths and reading)

A regression model was constructed to predict the average of maths gain and reading gain. The results suggested that 22% of the variance in pupils' academic learning gains in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the adaptation of programs to make ICT suit those with special needs (asad97) [-], and
- teachers' inclination towards the use of ICT in the classroom (td_97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
academic learning gain	asad97	-.41	.000	251
(t_r_voaa)	td_97	.31	.008	248
R-square = .22 (N=68) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-3) Pedagogical variables affecting performance in cognitive tasks and pupils' context score

(4-5-1-3a) A multiple regression model predicting non-verbal ability (in problems of position tasks)

The results of ANOVA test in the multiple regression statistic model suggested that 28% of the variance in pupil's performance in the non-verbal problems of position tasks in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the percentage of pupils in class who use a computer at home (it_psk) [+], and
- the preference for teaching literacy as opposed to numeracy^ (p_lang) [+]

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
problem of position task	it_psk	.46	.029	205
(t_o_zpp)	p_lang	.36	.079	75
R-square = .27 (N=35) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-3b) A multiple regression model predicting verbal ability (in picture vocabulary tasks)

The results of ANOVA test in the multiple regression statistic model suggested that 74% of the variance in pupils' performance in the picture vocabulary task in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- teachers' personal attitudes towards computers (af_com) [+],
- the percentage of pupils in class who use a computer at home (it_psk) [+], and
- the number of pupils in the teaching group or class ^ (aanp97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
picture vocabulary (t_o_zpv)	af_com	.53	.003	72
	it_psk	.48	.005	205
	aanp97	.28	.071	246
R-square = .74 (N=35) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-3c) A multiple regression model predicting context scores

A regression model was also constructed to predict the context score (see section 4-1 for further details). The results suggested that 66% of the variance in pupils' academic learning gains in 1997/98 could be explained by the simultaneous work of the following pedagogical variables (i.e. it happens that they are the same as E1-3b above):

- teachers' personal attitudes towards computers (af_com) [+],
- the percentage of pupils in class who use a computer at home (it_psk) [+], and
- the number of pupils in the teaching group or class ^ (aanp97) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Context score (t_o_zwe)	af_com	.47	.013	72
	it_psk	.45	.016	205
	aanp97	.32	.072	246
R-square = .66 (N=35) , the resullts of ANOVA sig. = .002				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-4) Pedagogical variables affecting pupils' attitudes towards academic tasks and towards themselves and the school

(4-5-1-4a) A multiple regression model predicting attitude towards maths tasks

The results of ANOVA test in the multiple regression statistic model suggested that 60% of the variance in pupils' attitudes towards maths tasks in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the planning of specific activities to support any computer programs that the teachers use (apso97) [-],
- teachers' perception of effects on pupils' academic achievement resulting from the use of computers (af_oac) [+], and
- the preference for teaching with open activities as opposed to closed activities (p_open) [+].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Attitude towards maths tasks	apso97	-.41	.015	251
(t_at_ma)	af_oac	.47	.008	67
	p_open	.38	.029	75
R-square = .60 (N=35) , the resullts of ANOVA sig. = .001				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-4b) A multiple regression model predicting attitude towards reading tasks

The results of ANOVA test in the multiple regression statistic model suggested that 19% of the variance in pupils' attitudes towards reading tasks in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the number of hardware/software add-ons on the computers ^ (cperi) [+], and
- the adaptation of programs to make ICT suit those with special needs ^ (asad97) [-].

Further details about the results of analysis can be found in the table below:

D.V.	I.V.	Beta	Sig.	N
Attitude towards reading	cperi	.32	.055	251
tasks (t_at_re)	asad97	-.31	.062	251
R-square = .19 (N=35) , the resullts of ANOVA sig. = .037				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

(4-5-1-4c) A multiple regression model predicting attitude towards themselves and the school

The results of ANOVA test in the multiple regression statistic model also suggested that 59% of the variance in pupils' attitudes towards themselves and the school in 1997/98 could be explained by the simultaneous work of the following pedagogical variables:

- the extent of the practical challenges perceived by the teacher in relation to the classroom usage of ICT (chl_f4) [-], and
- the preference for teaching with ICT as opposed to without ICT (p_ict) [+].

Further details about the results of analysis can be found in the table below:

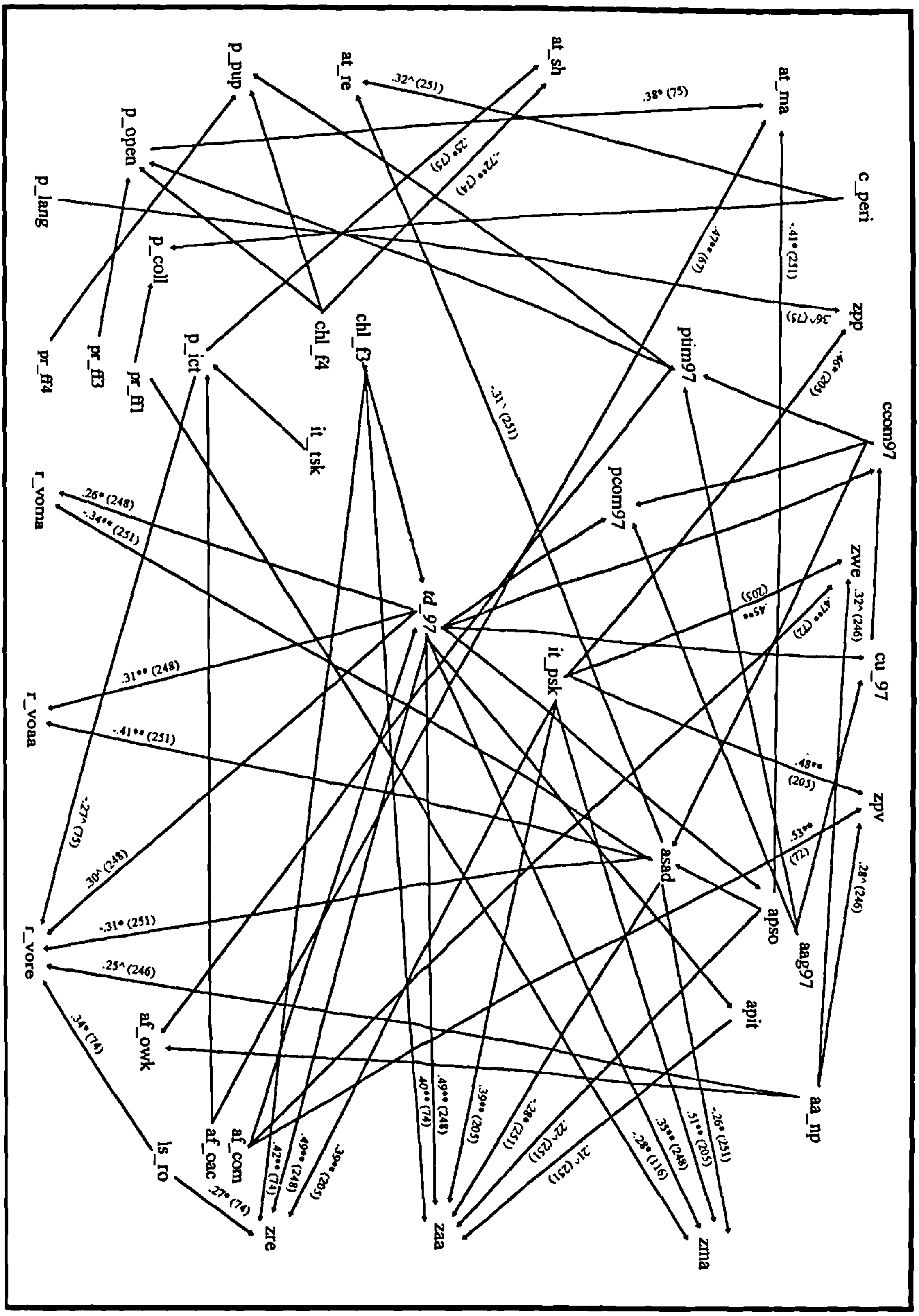
D.V.	I.V.	Beta	Sig.	N
Attitude towards themselves and the school (t_at_sh)	chl_f4	-.72	.000	74
	p_ict	.25	.030	75
R-square = .59 (N=69) , the resullts of ANOVA sig. = .000				

Keys/remark: ***D.V.*** refers to dependent variable, ***I.V.*** refers to independent variable(s), ***Beta*** refers to the standard regression, ***R-square*** refers to the coefficient of determination. The content of the I.V. is described in the text of this section

Discussion about pedagogical factors directly affecting teaching and learning outcomes

The graphical presentation of the results of these multiple regression models are presented in Illustration I4-2C. In the path diagram, a variable pointed by arrows is a dependent variable. Its value is affected by the simultaneous operation of a group of statistically significant factors. If it is the case that a variable is pointed at by only one arrow, it means that its value is affected and is predictable by a uniquely identified factor. A path coefficient is reported on each of the arrows in the diagram. It has a value between - 1.0 and + 1.0. The higher the value, the stronger the relationship between the dependent variable and the predictor. In the presence of a relationship, it can be positive or negative in nature. Some of the path coefficients are marked with a "**" or an "*". The coefficient of the former is statistically important in its contributions to predict the dependent variable at $p < 0.01$ level and that of the latter is at $p < 0.05$ level (two-tailed tests). A path coefficient marked with an "^" is not statistically strong enough to make independent contribution to the model (i.e. $0.05 < p < 0.10$), although it is making contributions to the statistical prediction of the dependent variable while acting as one of the multiple factors. Nevertheless, the coefficient of some paths in the diagram is not reported here. They are showing the causal relationships between these factors, which will be addressed in Illustration I4-2D. Readers can ignore these paths at this stage because they do not refer to the statistical results reported here.

Illustration I4-2C: Factors directly affecting the effectiveness of teaching and learning supported by ICT



Keys/Remark: Paths that do not have the coefficient reported in the diagram are not direct factors affecting learning outcomes. They are not included in the multiple regression analysis at this stage. The number in brackets refers to the sample size. The variable names in the diagram and their full names can be found in the results of multiple regression models in Section 4-5-1. ** refers to p < .01, * refers to p < .05 and ^ refers to .05 < p < .10.

I would like to draw attention to some key factors that have a direct impact on the outcome variables. The results of the model suggested that teachers' inclination towards the use of ICT in the classroom seemed to be an important factor affecting pupil academic attainments and academic learning gains. The relationships are consistently positive in nature and these applied to maths and reading. It means that the stronger the teacher's inclination towards the use of ICT in the classroom, the higher pupils' academic attainments and the higher their academic learning gains.

Note that the results are far from being ready for us to draw the conclusion that computers were effective in bringing about learning attainments and learning gains. The results of correlation statistics in 1997/98 showed that there was no direct relationship between any outcome variables and the frequency, intensity or the duration of computer usage, at $p < .05$ level with $N = 32$ to 67 (two-tailed). The closest significant finding was the impact of the amount of time that a typical pupil spent on the computer during an average week on pupils' attitudes towards maths, at $p < .05$ level with $N = 32$. The Pearson correlation statistic (r) was found to be - 0.37. So, it would be more likely that the impact brought about by teachers' inclination towards the use of ICT in the classroom originates from the characteristics of teachers, rather than from the extent of usage of technology. The results of correlation statistics showed that teachers who were generally positive about the use of ICT in their classroom were those who had high motivation and interest towards the use of ICT, at $p < .01$ level with $N = 67$. The Pearson correlation statistic (r) was 0.37. They were in possession of adequate IT skills and knowledge, at $p < .01$ level with $N=79$. The Pearson correlation statistic (r) was 0.42. And they were willing to adapt to the instructional challenges resulting from technological innovations, at $p < .01$ level with $N= 69$. The Pearson correlation statistic (r) was 0.40.

Classes that had adapted programs to make ICT suit those with special needs tended to have lower academic learning gains in reading and maths, and lower academic attainments in maths and reading, as reported in the path diagram. The complexity of lesson administration was a possible factor accounting for the low academic learning gains. Compared with other children in class, children with special educational needs might need more time or more teacher attention when they use computers. The higher the level of attention spent on SEN children, the lower the level of attention spent on the majority of the class. This explanation seemed to be slightly supported by the correlation statistic that also showed the presence of a positive relationship between adaptation of programs and planning specific activities for pupils with special needs, at $p < .01$ level with $N = 251$. The Pearson correlation statistic (r) was 0.34. No correlation was found between the adaptation of programs and the number of pupils on the special educational needs register, at $p < .05$ with $N = 250$.

Partial correlation technique consistently showed that the adaptation of programs to make ICT suit those with special needs was negatively associated with pupil academic learning gains in maths and reading, when the number of special needs children in class was taken into account, at $< .05$ level with $N = 64$ and 64. The Pearson correlation statistic (r) are -0.30 and -0.34, respectively. Nevertheless, the results of partial correlation did not find a significant relationship between the adaptation of programs to make ICT suit those with special needs and pupil academic attainment in maths or reading, when the number of special needs children in class was take into account, at $p < .05$ level with $N = 64$ and 64. The Pearson correlation statistic (r) are -0.18 and -0.17, respectively. This would imply that the adaptation of programs to make ICT suit those with special needs hinders academic progress in maths and reading, although it might not bring down academic standards in each of the two subjects when the number of special needs children in class is taken into account. The decision for an adaptation of programs seemed to be a result of the subjective judgement or preference made by the teacher because it was not related to the number of pupils on the special educational needs register. However, the negative impact of the practice was unexpectedly high because it affects the effectiveness of instruction with and without the use of ICT. So, the results imply that it would be an ineffective practice to spend too much time and effort on the use of ICT for a small group of pupils in class, when the progress of the majority of the class may be slowed down.

The planning of specific activities to support computer programs was positively related to the academic learning attainment measure. Similarly, the specification of ICT in teachers' weekly planning was also positively related to the average learning attainment measure. The implication on the basis of these findings, as mentioned above, is that the frequency, the intensity or the duration of usage of computers in the classroom does not seem to be related to academic attainments or academic learning gains. Instead, careful planning for the regular use of ICT involving proper integration with other teaching activities is positively associated with pupils' learning attainments. Planning in terms of the adaptation of programs for those with special educational needs, however, can be too demanding for teachers in practice. This suggests that planning and pedagogical arrangements were positive towards learning attainment, but when too much time and effort were used to serve a small group of pupils in class, computer use could have a negative impact on pupils' academic progress.

The institutional and work-related challenges presented by the classroom usage of ICT were found to be positively related to pupils' reading attainment and the average attainment measure. This may imply that teachers who were concerned about their duties and workload resulting from the use of ICT had performed better than the teachers who did not because their concerns made them work hard. Those who were aware of and responded to the increase in workload resulting from the use of ICT would have a more balanced view of the cost-effectiveness of using ICT. In considering whether to use ICT or not, their awareness might lead to a better pedagogical decision in terms of the effectiveness of teaching and learning as a whole.

The percentage of pupils in class who used a computer at home was found to be a significant factor affecting pupils' academic attainments. All the significant relationships were positive in nature. The higher the percentage, the higher the average scores that the class got in the respective PIPS tests. These included tests on pupils' reading attainment and maths attainment. The results also suggested that the percentage of pupils in class who used a computer at home did not seem to have a higher than expected academic learning gains, as reported in the diagram. If this is true, the results suggested that the use of computers at home did not bring them higher than average learning gains. Alternatively, it is possible that the percentage of pupils in class who used computers at home is an indicator of social-economic advantage in relation to home background. If this is the case, pupils gains in achievement in academic and cognitive areas may be a result of various factors (e.g. study environment), not only from the use of computers. In this study, no further information was learned on the usage of computers at home. They could be used for educational learning, for entertainment, or even both. If this is true, the extent of learning gain was not related to the use of computer at home.

Correlation statistics also indicated that the percentage of pupils in class who used computers at home was associated with a higher average context score (at $p < .01$ level with $N = 28$ and $r = 0.55$) and a higher average picture vocabulary test score (at $p < .01$ level with $N = 28$ and $r = 0.59$). The results indicated the possible link between using computers for out-of-school learning and pupils' verbal and non-verbal abilities. However, reader should note that the use of a computer at home doesn't mean that the pupil is using it for out-of-school learning. It could be used for entertainment purposes, such as playing computer games. The ownership could be interpreted as a kind of socio-economic advantage gained by the group pupils in class. That makes home background an alternative explanation for the results. Nevertheless, the results could also be affected simultaneously by the two factors.

The path model also suggests that teachers' reflective observation orientation in learning significantly affects pupils' reading attainment and reading gains. Further investigation was also made by checking the magnitude of the correlations between reflective observation orientation of learning and each of the learning attainment/gain/attitude measures. It was found that all of these correlation statistics were positive, although no other results were found to be statistically significant, at $p < .05$ with $N=36$ in each pair of variables. So, the positive relationship between reflective observation and reading attainments/gains was supported. The results may imply that teachers need to pay careful attention to observing pupils' behaviour in reading. By doing so, under-achieving pupils can be identified and remedial actions can be taken. Watching children read can also make pupils feel that they are supported or supervised by the teacher for the benefit of their own learning. Furthermore, effectiveness might be accelerated by teachers' reflection on their language used in the classroom. Language inputs/examples of high quality would foster pupils' improvement in their use of English language and their reading standard/progress.

Teachers' personal attitudes towards computers had a significant impact on their pupils' context score and on their pupils' performance in the picture vocabulary task, respectively. The more positive the teachers' personal attitudes towards computers, the higher the context scores that their pupils obtained and the higher the scores that their pupils attained in the PIPS picture vocabulary test. The results of correlation statistics further suggested that those teachers who liked computers tended to have better computer skills/experience, (at $p < .01$ level with $N = 70$ and $r = 0.59$), a stronger inclination towards the use of computers in the classroom (at $p < .01$ level with $N = 67$ and $r = 0.37$), a preference for open activities as opposed to closed activities (at $p < .01$ level with $N = 42$ and $r = 0.39$) and high *premise self-reflection* of their own teaching (at $p < .01$ level with $N = 72$ and $r = 0.37$). Teachers' premise self-reflection also has a positive impact on pupils' thinking skills. These personal qualities create an investigative learning environment for promoting pupils' acquisition of information processing abilities. As pupils are encouraged to take an active role in constructing their own knowledge, they perform well in cognitive tasks.

Teachers' preference for teaching literacy as opposed to numeracy also had a significant impact on pupils' performance in the non-verbal problems of a position test. The stronger the teachers' preference in teaching literacy, the better their pupils' performance in non-verbal cognitive tasks. Effective teachers of literacy are eager to pay attention to their pupils' development in language arts. Pupils are probably encouraged to be creative and to use imagination in their work. Therefore, it is possible that the teaching approach that most literacy-based teachers use facilitates the development of mental pictures. On the other hand, many maths tasks at primary education level are mechanical in nature.

The results suggest that the number of pupils in the teaching group made a contribution to the prediction of pupils' picture vocabulary test scores and pupils' reading gains. The relationships were positive in nature. The higher the number of pupils in the teaching group, the higher the pupils' picture vocabulary scores and the higher the pupils' reading gains. Schools that have good academic reputations have large class sizes because many parents prefer them. Statistics showed that this factor did not seem to play a very important role in predicting the target variables.

The implementation of teaching practice as a habitual action or routine had a negative effect on pupils' maths attainment. Pupils could break down at any mathematical stage. Their maths attainment could be hindered by the teacher's lack of attention to problems that individual pupils encountered.

Pupils' attitudes towards maths was significantly affected by the teacher's preference towards open activities as opposed to closed activities and the perception of academic achievement resulting from the use of computers. The higher the preference for open activities as opposed to closed activities, the higher the pupils' attitudes towards maths. The more positively the teacher perceived that academic achievement resulting from the use of computers, the higher the pupils' attitudes towards maths. However, the results indicated that planning specific activities to support a computer program that the teacher used was negatively related to the pupils' attitude towards maths. Given that planning specific activities to support a computer program that the teacher used was positively related to pupils' learning gain, the present result was rather unexpected.

A possible explanation could be the discrepancy between the effectiveness of the activities that support a computer program and pupils' attitude towards these activities. If this is true, the results would have suggested that pupils have a positive attitude towards maths when they work on open activities, but have a negative attitude towards maths when they work on closed activities. Pupils might like to play with numbers, but not repetitive drill and practice mathematical exercises. They might have a positive attitude towards maths activities on the computers as fun, but they might not like the non-computer activity that is planned by the teacher to support a specific computer program. For example, pupils might be excited with the exploration on a LOGO computer program. Their attitude towards the topic could become negative when they move on to the extended activity with paper and pencil.

The provision of hardware/software add-ons also had a positive correlation with pupils' attitudes towards reading (at $p < .05$ level with $N = 35$ and $r = 0.35$). In other words, the higher the number of add-ons, the higher the satisfaction pupils got from their reading task. The result is consistent with the significant positive correlation found between the provision of hardware/software add-ons and pupils' attitudes towards maths (at $p < .05$ level with $N = 35$ and $r = 0.39$). The adaptation of programs to make ICT suit those special needs had a negative correlation with pupils' attitudes towards reading (at $p < .05$ level (one-tailed) with $N = 35$ and $r = -0.29$).

Note that the availability of a CD-ROM, a printer, a hard-disk drive, ILS software or an internet access point was counted as an add-on item. The higher the number of add-ons, the higher the technical readiness for the computers to present learning activities in an interactive and/or multimedia mode. The fancy features available from computers made the learning experience attractive to many pupils. As the model suggested that the two pedagogical variables worked reasonably well together as predictors of attitude towards reading, it would mean that pupils generally liked working on fancy activities on high-performance computers. However, when teachers gave too much time and effort for children with special educational needs to use computers, the reading attitude of the majority of the class could be affected negatively.

The path model suggested that the measure concerning teachers' preference for ICT activities as opposed to non-ICT activities was positively related to pupils' attitudes towards themselves and the school, but it was negatively related to pupil reading gains. Teachers' perception of the practical challenges for reliable equipment, technical support and additional support available to individual pupils was also positively related to pupils' attitudes towards themselves and the school. It also indicated that teachers' attempt to use computers in the classroom were generally welcomed by pupils. As a result of their perception of the pupils' support towards the use of computers, positive actions could benefit pupils with a better quality of school life, although the progress of learning could be hindered by various difficulties met in using computers. They will be summarised in the paragraph below.

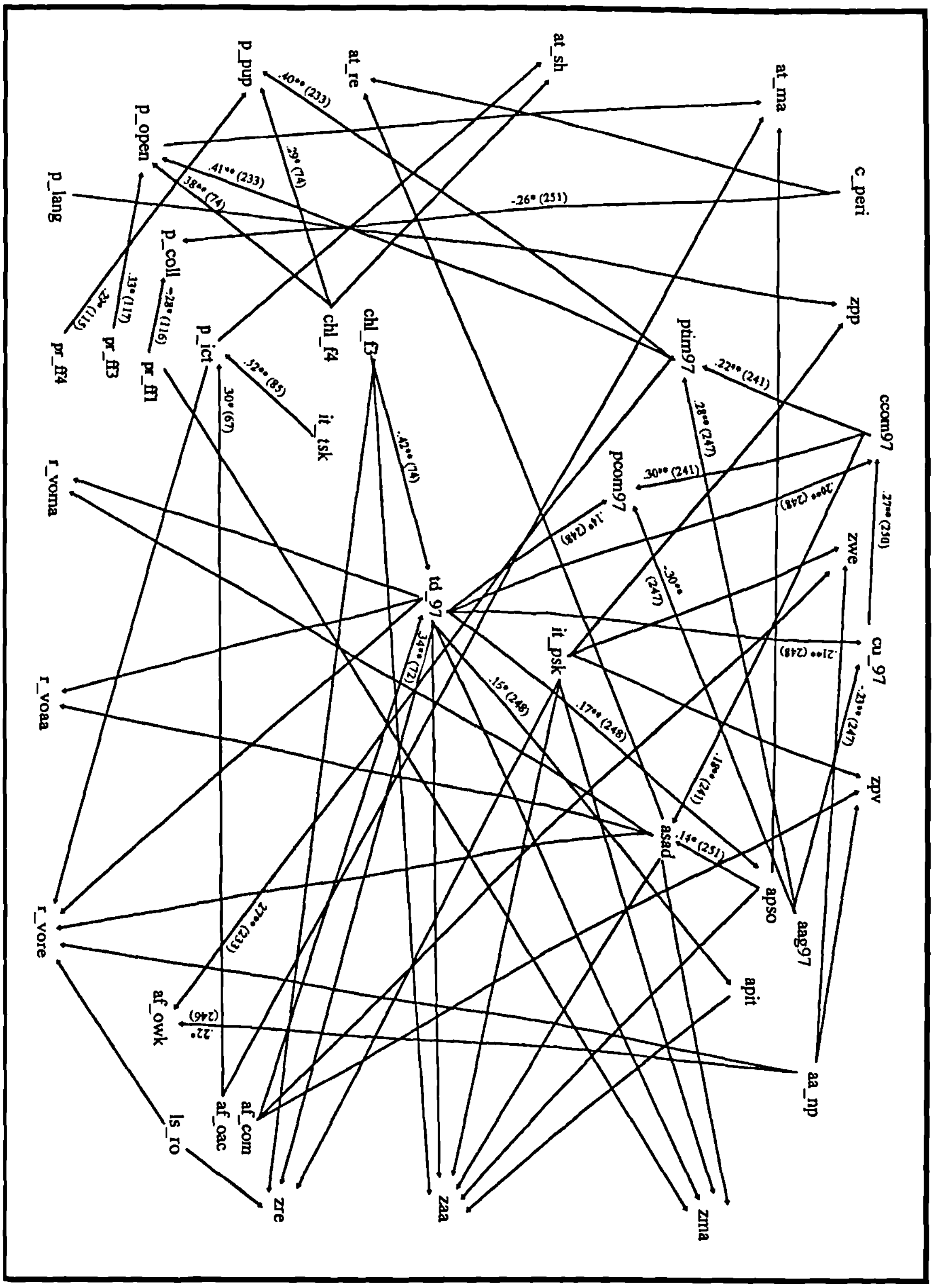
In relation to the discussions above, successful use of computers often requires certain personal qualities of the teacher. An ideal person would be someone who has strong motivation or incentive to teach with new methods, is ready or willing to adjust themselves for instructional changes. Time and effort spent on planning would generally make contributions to learning. An effective teacher-user of ICT might be someone who plans specific activities to support the computer programs to be used and specifies the use of IT in their weekly plan. Having said that, the teacher should be able to make clever pedagogical judgement/decisions concerning whether to use or not use ICT for a specific topic or activity. It would be someone who seriously considers the duties and workload resulting from the use of ICT, rather than someone who uses ICT to fulfill their own wishes or pedagogical preference. He/she needs to avoid paying too much attention to preparing or using the computers for a small group of pupils, such as those with special educational needs in the class, while the majority of the class is neglected. Finally, a successful use also depends on the pupils' experience or exposure to computers. An effective teacher-user of computers is likely to have pupils whose IT skills/experience have been improved through home computer usage.

(4-5-2) Inter-relationships between pedagogical factors

(4-5-2-1) Inter-relationships between pedagogical factors directly affecting outcomes and some other factors affecting the pedagogy concerning the use of ICT

In this section, we are going to look at the relationships between the above teaching and learning process factors and some other key process factors concerning the use of ICT. The relationships are summarised in the path model presented in Illustration I4-2D. Each of these path coefficients was found to be statistically important in its contribution to predict the dependent variable either at $p < 0.01$ level or at $p < 0.05$ level (two-tailed tests). Compared with variables mentioned in Illustration I4-2C above, two groups of variables are new in this section. These include variables concerning the extent of computer usage and variables concerning teachers' pedagogical preference. By linking these variables together for statistical investigations, it is hoped that we can discover more about the formulation of pedagogical judgements or pedagogical decisions concerning the use of ICT for supporting subject teaching and learning.

Illustration I4-2D: Inter-relationships between pedagogical factors directly affecting outcomes and some other factors affecting the the use of ICT



Keys/Remark: Paths that do not have the coefficient reported in the diagram are direct factors affecting learning outcomes. They are not included in this multiple regression analysis, but reported here as reference. Their path coefficients can be found in Illustration I4-2c. The number in brackets refers to the sample size. The variable names in the diagram and their full names can be found in Section 4-5-2-1. ** refers to $p < .01$ and * refers to $p < .05$.

Teachers' inclination towards the use of ICT in the classroom seemed to be an important co-ordinating factor. The results of multiple regression analyses suggested that it was positively affected by teachers' personal attitudes towards computers and negatively affected by teachers' perceptions of institutional and work-related challenges concerning the usage of ICT. The higher the teacher's personal attitude towards computers, the stronger the teacher's inclination towards the use of ICT in the classroom, and vice versa. The greater the institutional and work-related challenges that the teacher perceived, the weaker the teacher's inclination towards the use of ICT in the classroom (td_97), and vice versa. Teachers' inclination towards the use of ICT in the classroom was a significant factor that positively affecting some other instructional and learning process factors. These factors include:

- the frequency of computer use by the class (ccom97),
- the opportunity for a typical pupil in class to have a turn on the computer (pcom97),
- the frequency of using computers for curriculum purposes (cu_97),
- the planning of specific activities to support a computer program that was used (apso), and
- the specification of ICT in teachers' weekly planning (apit).

The results also suggested that there were close relationships between variables measuring the frequency, opportunity and the amount of time using computers in primary education. And these variables were affected by the year of the teaching group. Pupils in upper primary had less opportunity to have a turn using a computer and less usage of computers for curriculum purposes than pupils in lower primary. However, pupils in upper primary spent more time on the computers than pupils in lower primary did. The findings seemed to be a reasonable explanation for instructional arrangements in which the attention span of young children was taken into account. A pupil in lower primary education levels had more opportunity to have a turn on the computer and spent a shorter length of time on the computer than a pupil in upper primary education levels, as reported in section 4-4-B1. Similarly, an older child in primary education seemed to spend longer time and had less chance of having a turn on the computer than a pupil in lower primary education.

How often the class used a computer was also affected by the teacher's tendency towards the use of computers and the frequency of using computers for curriculum purposes. The frequency that the class used a computer had positive impact on the opportunity for a typical pupil in class to have a turn on the computer and the amount of time that a typical child spent on the computer during an average week. The more often the class used a computer, the more likely that a typical pupil in class had a turn on the computer and the larger the amount of time that a typical child spent on the computer. There was no significant correlation between the opportunity for a typical pupil in class to have a turn on the computer and the amount of time that a typical child spent on the computer, at $p < .05$ level with $N=228$.

The measure concerning the adaptation of programs to make ICT suit those with special needs was found to be positively affected by the frequency that the class used a computer and the planning of specific activities to support a computer program that was used. Teachers who adapted the use of programs to suit those with special needs were more likely to have a high frequency of using computers in the class than those who did not. They were more likely to plan specific activities to support a computer program that was used than those who did not adapt the use of programs.

The measure concerning the extent of the perceived teaching workload resulting from the use of ICT to support subject teaching (af_owk) was affected by a combination of these two process factors:

- the number of pupils in the class (aa_np), and
- the amount of time that a typical child spent on the computer during an average week (ptim97).

The relationships were positive in nature. That meant, the larger the amount of time that a typical child spent on the computer during an average week, the greater the perceived teaching workload resulting from the use of ICT to support subject teaching, and vice versa. Similarly, the larger the number of pupils in class, the greater the perceived teaching workload resulting from the use of ICT to support subject teaching.

The bottom left of the path diagram focuses on the characteristics of the teacher. These include measures of teachers' reflective practice and of their pedagogical preferences. Unlike the other variables in the diagram, the arrows to be used here are one-sided arrows. That means, the measures of pedagogical preference were predicted by the simultaneous work of a group of pedagogical variables in the path diagram, but none of these measures was used to predict the value of the other variables. The major reason was that the aim of the investigation was in the determinants of teachers' pedagogical preference, rather than the impact of these preferences.

The results showed that the measure concerning teachers' preference for using ICT as opposed to not using ICT (p_ict) was positively affected by teachers' IT skills and knowledge (it_tsk), as well as their perception of the effects on academic achievement resulting from the use of computers for subject teaching and learning (af_oac). The combination of these factors explained 39% of its variance. The results would mean that teachers who preferred using ICT were those who had reasonable knowledge and skills in IT and they had developed the feeling that computers could make contributions to the academic achievement of pupils.

The results showed that the measure concerning teachers' preference for pupil control in learning as opposed to teacher control (p_pup) was significantly affected by the following factors:

- the amount of time that a typical child spent on the computer during an average week (ptim97),
- teachers' perceptions of the practical challenges for reliable equipment, technical support and additional support available to individual pupils (chl_f4), and
- implementation of teaching practice with premise self-reflection (pr_ff4).

The results also showed that the measure concerning teachers' preference for open activities as opposed to closed activities (p_open) was significantly affected by the following factors:

- the amount of time that a typical child spent on the computer during an average week (ptim97),
- teachers' perceptions of the practical challenges for reliable equipment, technical support and additional support available to individual pupils (chl_f4), and
- implementation of teaching practice with critical reflection (pr_ff3).

The results of the prediction of the two preference measures were quite similar to each other. The combination of the first group of factors explained 31% of the variance of the data concerning teachers' preference for pupil control in learning, and the combination of the second group of factors explained 34% of the variance of the data concerning teachers' preference for open activities. All the significant relationships found were positive.

It may be that teachers who preferred pupil control in learning to teacher control in learning, as well as teachers who preferred open activities to closed activities, were relatively open-minded in their personality. Teachers of this type were willing to allow individual pupils to spend time on the computer. They were aware of and made responses to practical challenges concerning the use of computers in the classroom and liked to implement their teaching practice with critical reflection and premise self-reflection. As they were able to make adjustments and improvements in their own practice, they were equipped to cope with practical challenges concerning the use of computers, such as the lack of reliable equipment, the provision of technical support and extra support for individual pupils.

The results showed that the measure concerning teachers' preference for collaborative activities as opposed to individual activities (p_coll) was positively affected by the number of hardware/software add-ons (cperi) and the implementation of teaching practice as a routine or habitual action (pr_ff1). The combination of the two factors explained 13% of the variance of the measure concerning teachers' preference for collaborative activities. This might imply that teachers who preferred individual activities tended to implement their teaching in a routine way, and vice versa. The results of correlation statistics further indicated that the preference for individual activities were positively related to the preference for not using ICT and the preference for teacher controlled and closed activities, at $p < .01$ level with all the $N = 75$ and $r = 0.52$, 0.48 and 0.46, respectively. It might be sensible to speculate that this type of teacher may assign their high-performance computers, if there are any, to use by individual pupils for closed and teacher-led activities. They would lack the idea or the incentive to think of some innovative usage of the capabilities and features of powerful computers that they have access to.

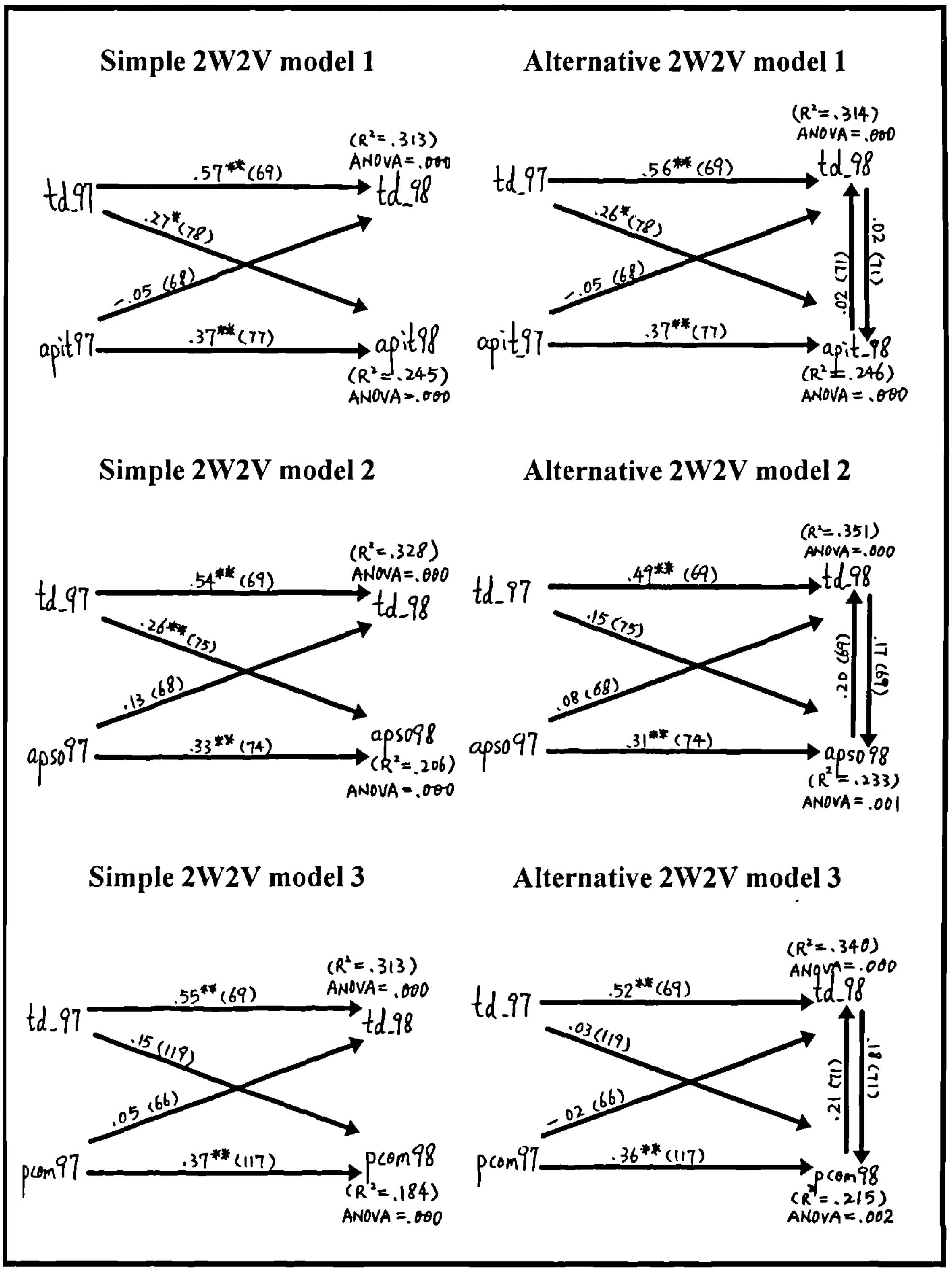
(4-5-2-2) Clarifications of causal relationships

The use of multiple regression technique in path modelling has its own limitations. As a special case of structural equation modelling, path modelling adopts a non-recursive system flow. The relationship between an independent variable and a dependent variable must be expressed as a unidirectional system. Therefore, the incompatibility of expressing bi-directional relationships is a limitation of the proposed path model. Multiple regression technique is reasonably good at using one or a group of independent variables to predict a dependent variable. However, a major limitation of the technique is that the relationship between a predictor variable and a predicted variable may not be appropriate to be interpreted as a causal relationship with the independent variable as the cause and the dependent variable as the outcome. For example, a typically difficult relationship occurs when variable A is one of the significant predictors for variable B, and using the same set of data, variable B is also one of the significant predictors for variable A. Therefore, the identification of the cause and the effect is a typical weakness in the application of multiple regression technique in causal modelling.

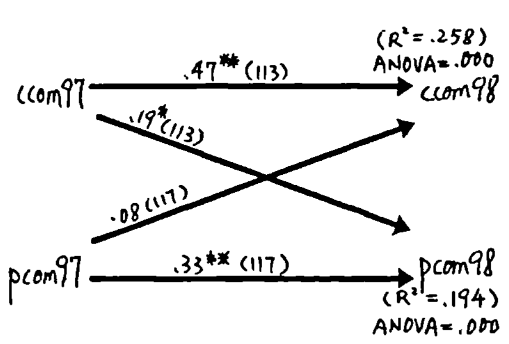
To deal with the methodological weakness above, a series of procedures was carried out to help the identification and clarification of cause and effect variables. Firstly, the meanings of the identified pair of variables were checked against their compatibility in relation to the teaching and learning context. Hypothetical relationships that were found to be counter-intuitive were either dropped out or refined. Secondly, a cross-check of the significant predictors for each of the pair of variables was carried out. For example, if variable A is found to be one of the significant predictors for variable B and variable B is not found to be one of the significant predictors for variable A, the results mean that the hypothesis that variable A is a "cause" of variable B is supported by the data. The results also mean that the hypothesis that variable B is a "cause" of variable A is not supported by the data.

In relation to the causal relation that was found to be typically difficult, as mentioned above, a third procedure was also used. The procedure was applicable for pairs of variables where data was collected in both academic year 1997/98 and year 1998/99. Technically speaking, the data is named "two-wave two-variable" (2W2V) data. The idea is to construct two hypothetical models and justify which one of the two alternatives seems to be a better inference of the data, through comparison of the strength of the two targeted causal relationships. An example of the procedure using authentic data from this study is presented in Illustration I4-2E, which contains graphical presentations of these 2W2V models.

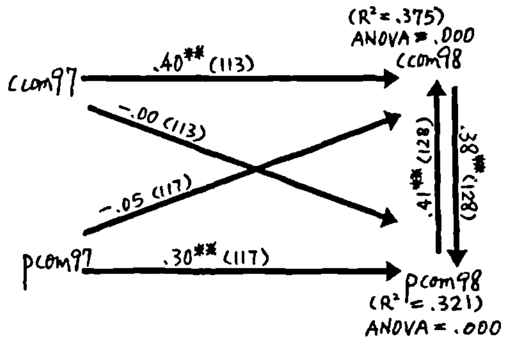
Illustration I4-2E: The results of seven two-wave two-variable (2W2V) path models



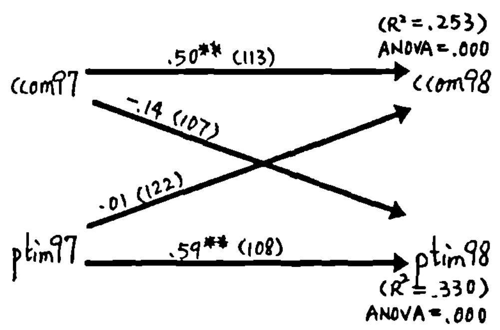
Simple 2W2V model 4



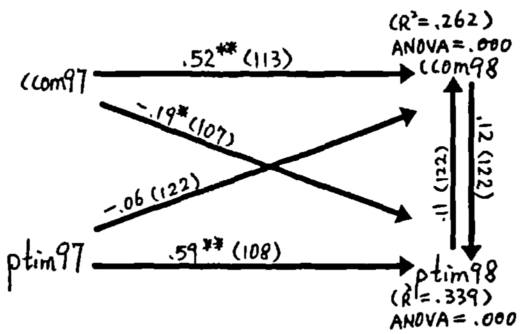
Alternative 2W2V model 4



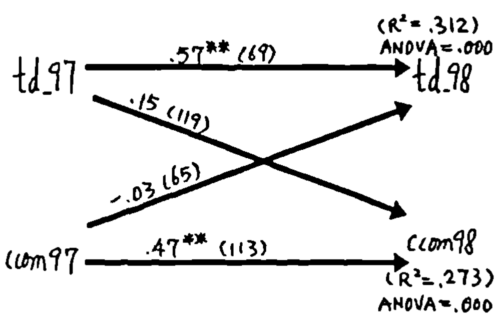
Simple 2W2V model 5



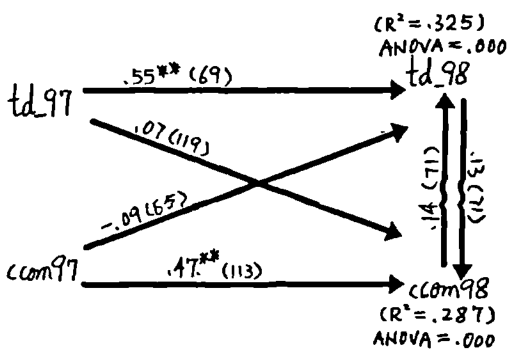
Alternative 2W2V model 5

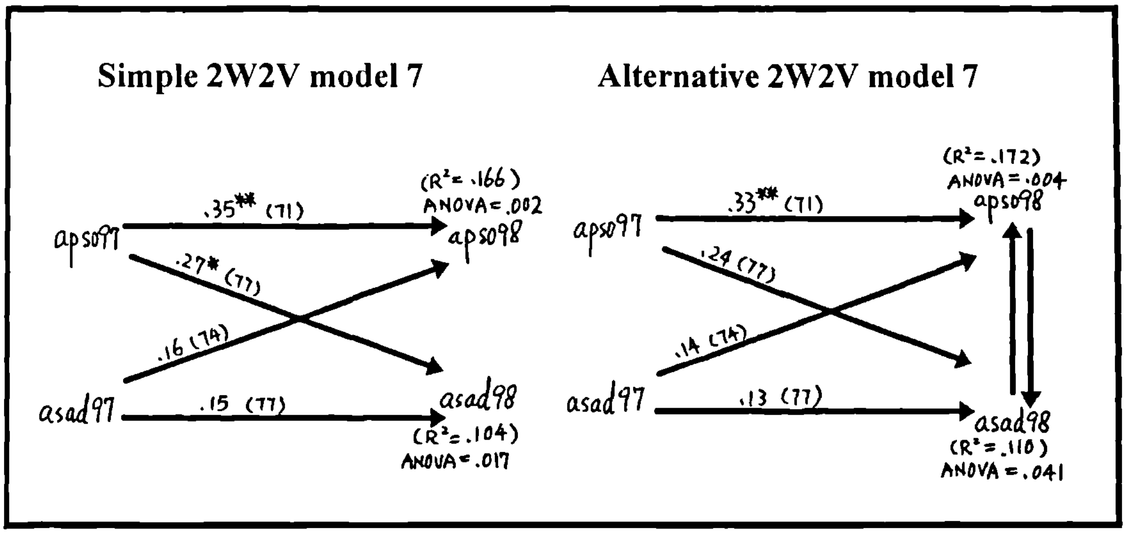


Simple 2W2V model 6



Alternative 2W2V model 6





Keys/Remark: Each of the simple models is made up of two regression models, and each of them has two predictors. Each of the alternative models is also made up of two regression models, and each of them has three predictors. The number in brackets refers to the sample size and the preceding number refers to the path coefficient. The variable names in the diagram and their full names can be found in the discussion of the multiple regression analysis results in Table D4-T4-2f and in *Section* 4-5-2-2. ** refers to $p < .01$ and * refers to $p < .05$.

In referring to the first simple causal model in the illustration, the specification of ICT in teachers' weekly planning in 1998/99 (second wave first variable) was predicted by the combination of the specification of ICT in teachers' weekly planning in 1997/98 (first wave first variable) and teachers' inclination towards the use of ICT in the classroom in 1997/98 (first wave second variable). Statistical results showed that the relationship of the first pair of variables, which was technically named as "auto" relationship, was found to be statistically significant, at $p < .01$ level with N = 77. The path coefficient, 0.37, was an indicator of the strength of the relationship. The relationship of the second pair of variables, which was technically named as "cross-lagged" relationship, was also found to be statistically significant, at $p < .01$ level with N = 78. The path coefficient, 0.27, was an indicator of the strength of the relationship. In the causal model, teachers' inclination towards the use of ICT in the classroom in 1998/99 (second wave second variable) was predicted by the combination of the specification of ICT in teachers' weekly planning in 1997/98 (first wave first variable) and teachers' inclination towards the use of ICT in the classroom in 1997/98 (first wave second variable). Statistical results showed that of the first pair of variables was not found to be statistically significant, while the second pair of variables was found to be statistically significant, at $p < .01$ level with N=69.

In a brief review of the use of 2W2V modelling technique for analysing causal relationship, Plewis (1985) pointed out the popularity of using the procedure of comparing the cross-lagged correlation statistics to identify cause and effect. In a pair of cross-lagged relationships, it is reasonable to conclude that the stronger relationship is cause and the weaker relationship is the effect. Furthermore, he pointed out that it would be more appropriate to consider the comparison of the strength of cross-lagged relationships in multiple regression models. That would mean he was suggesting that partial correlation measures were fairer comparison indicators than traditional correlation measures. Therefore, by comparing the two cross-lagged *relationships* mentioned above, it is reasonable to conclude that teachers' inclination towards the use of ICT in the classroom was the cause for the specification of ICT in teachers' weekly planning. Series of simple 2W2V causal models were formulated to analyse the causal relationships in the path model. The correlation statistics of these pairs of variable and the conclusion about the causal relationships are presented in Table T4-D4-2f. The valid sample size for these correlation procedures was between 74 and 248.

Table T4-D4-2f: The results of the correlation statistics and the conclusion about the causal relationship of the two target variables

	Name of variables	Correlation	Conclusion about the causal relationship
1	td_97 & apit97	.16**	td_97 is the cause of apit97
2	td_97 & apso97	.17**	td_97 is the cause of apso97
3	td_97 & pcom97	.21**	td_97 is the cause of pcom97
4	ccom97 & pcom97	.36**	ccom97 is the cause of pcom97
5	ccom97 & ptim97	.20**	ccom is the cause of ptim97
6	td_97 & ccom97	.25**	td_97 is the cause of ccom97
7	apso97 & asad97	.15*	apso97 is the cause of asad97

Keys: *N* refers to the sample size. * refers to $p < .05$ and ** refers to $p < .01$. ***td*** refers to inclination towards using computers, ***apit*** refers to the specification of ICT in teachers' weekly planning, ***apso*** refers to the planning of specific activities to support any computer programs that the teacher use, ***pcom*** refers to the intensity of pupil computer usage (i.e. opportunity for a typical pupil in class to have a turn on the computer), ***ccom*** refers to the frequency of class usage of computers, ***ptim*** refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week), ***asad*** refers to the adaptation of programs to make ICT suit those with special needs.

Simple 2W2V causal modelling technique has it own limitations in use. Its assumption that there is no simultaneous effect between the two variables in the second wave is a major controversial issue. The weakness can be improved by careful model specification. For instance, in addition to the simple 2W2V causal model, specifying the second wave second variable as an additional predictor in the prediction of the second wave first variable; and specifying the second wave first variable as an additional predictor in the prediction of the second wave second variable. In fact, simple causal models were quite acceptable because their results were reasonably consistent with the results of the alternative models. Details of the direction and the size of the cross-lagged relationships of the simple causal models and those of the alternative causal models are summarised in Table T4-D4-2g.

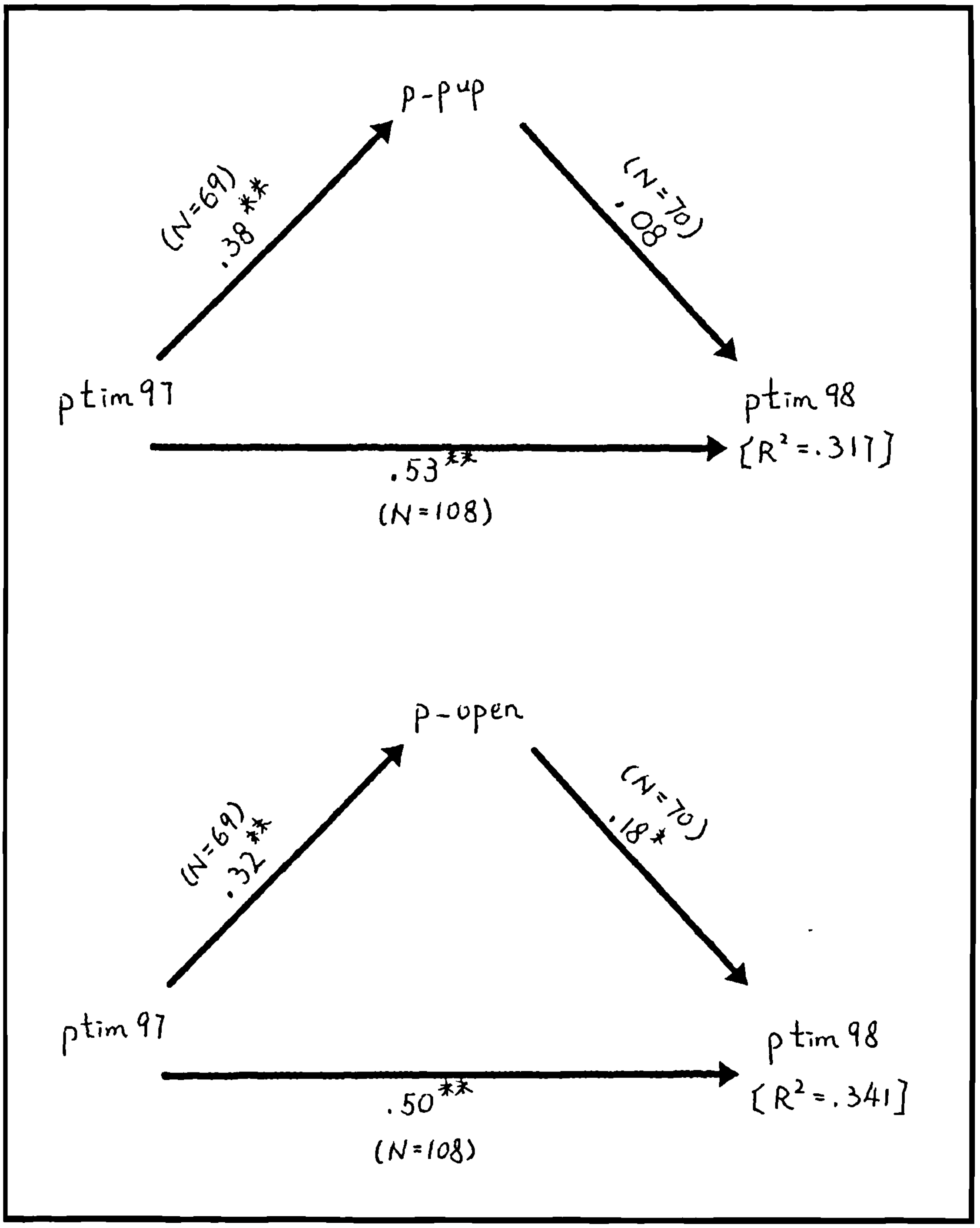
Table T4-D4-2g: **The results of two-wave two-variable path models analysing the correlations and the causal relationship of the two target variables**

			Simple 2W2V model	**Alternative 2W2V model**			**Simple 2W2V model**	**Alternative 2W2V model**
	Name of cross-lagged variables	**Correlation**	**Coefficient (Beta)**	**Coefficient (Beta)**	**Name of cross-lagged variables**	**Correlation**	**Coefficient (Beta)**	**Coefficient (Beta)**
1	td_97 & apit98	.33**	.27*	.26*	apit97 & td_98	.04	-.05	-.05
2	td_97 & apso98	.31**	.26*	.15	apso97 & td_98	.22	.13	.08
3	td_97 & pcom98	.23*	.15	.03	pcom97 & td_98	.16	.05	-.02
4	ccom97 & pcom98	.31**	.19*	-.00	pcom97 & ccom98	.25**	.08	-.05
5	ccom97 & ptim98	-.02	-.14	-.19*	ptim97 & ccom98	.106	.01	-.06
6	td_97 & ccom98	.27**	.15	.07	ccom97 & td_98	.11	-.03	-.09
7	apso97 & asad98	.29*	.27*	.24	asad97 & apso98	.21	.16	.14

Keys/**Remark:** *N* refers to the sample size, ***Beta*** refers to the standard regression. * refers to p < .05 and ** refers to p < .01. ***td*** refers to inclination towards using computers, ***apit*** refers to the specification of ICT in teachers' weekly planning, ***apso*** refers to the planning of specific activities to support any computer programs that the teacher use, ***pcom*** refers to the intensity of pupil computer usage (i.e. opportunity for a typical pupil in class to have a turn on the computer), ***ccom*** refers to the frequency of class usage of computers, ***ptim*** refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week), ***asad*** refers to the adaptation of programs to make ICT suit those with special needs.

Readers should note that there were other 2W2V models done to investigate the causal relationship between two pedagogical variables. Instead of reporting all the findings, only those that made contributions to the differentiation of cause and effect relationship are reported here. Furthermore, it is worthwhile to note that the identification of cause and effect relationship between variables collected at different time can be complex. Generally speaking, a variable collected at an earlier time is likely to be the cause and a variable collected at a later time is also likely to be the cause. Having said that, data variables collected at different times could have a reciprocal relationship. For instance, each of the two measures of pedagogical preference presented in Illustration I4-2F (i.e. p_pup & p_open) was affected by the amount of time a typical pupil spent on the computer in a week in 1997/98 (ptim97), and each of the two measures also affected the amount of time a typical pupil spent on the computer in a week in 1998/99 (ptim98). The relationship is not only statistically plausible, but it is also theoretically sound. The formulation or refinement of pedagogical judgements is sometimes an on-going process that takes time to develop. Pedagogical preference concerning the classroom usage of computers may be determined by the actual experience or feedback received by the teacher. After adjustments or improvements in pedagogy concerning the use of ICT have been made, there will be corresponding changes in the practice of the teacher. So, there is a time lag between the teacher's perception, the change in teacher characteristics and the resulted change in pedagogical practice. And the statistical results presented in Illustration I4-2F demonstrate that the relationship between the preference for open activities as opposed to closed activities (p_open) and the amount of time that a typical pupil spent on the computer in a week (ptim) was 'reciprocal' in nature, at $p < .01$ and $p < .05$ levels (one-tailed). That means the two variables affect each other on a longitudinal basis.

Illustration I4-2F: The relationships between pedagogical preference and the amount of time that a typical pupil spent on the computer



Keys/Remark: The number in brackets refers to the sample size and the preceding number refers to the path coefficients. The variable names and their full names can be found in Section 4-5-2-1. ** refers to $p < .01$ and * refers to $p < .05$. ***ptim*** refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week), ***p_open*** refers to the preference for teaching with open activities as opposed to closed activities and ***p_pup*** refers to the preference for pupil control in learning as opposed to teacher control in learning.

Summing up

As a brief summing up of the findings above, it would be useful to integrate the two groups of findings. It contains direct relationships between pedagogical and instructional factors and learning outcomes as well as the inter-relationships between these factors.

(4-5-3) Applying the proposed model to predict learning attainments

(4-5-3-1) Triangulation/Re-examination of the proposed model

Note that the proposed model presented in Illustration I4-2C or I4-2D was formulated on the basis of the data collected mainly from reception, year 2 and year 4 classes in 1997/98. Due to the wide spread of the year group of the samples, the proposed relationships could be used as a reference for describing the pedagogical and instructional practice concerning the use of ICT that generally applies to primary classrooms in England. Having said that, it is still unsure how good the model is at describing the practice of a particular year group, let's say reception year.

One of the ways of verifying this is to apply the model to data of a particular year group, and see how good the model is at explaining the data. This forms the rationale of verifying the proposed model by the spit-half method. As the originally proposed model appeared to be promising in predicting pupil learning attainment, variables in the model will be used to predict the learning attainments of reception classes. This forms the first half of the sample. Then the model will be used to predict the learning attainments of the second half of the sample, which were obtained from year 2 and year 4 classes.

(4-5-3-2) Applying the proposed model to predict learning attainments

The results of the prediction models were summarised in Illustration I4-2H. It contains 3 series of multiple regression models. The first series of models were used to predict pupil's maths learning attainment in 1997/98. There were 3 models of prediction without control for ability and 2 models of prediction with control for ability. A prediction model with control for ability refers to the inclusion of pupils' scores in 'picture vocabulary' test and pupils' scores in 'problems of position' test in the group of predictors. That would mean, pupils' verbal and non-verbal abilities were taken into account in prediction models with control for ability. There wasn't any measure of abilities in reception year, so there was no control for ability in any of the respective prediction models.

Illustration I4-2H: Fitness of original model

Fitness of the original model: Applying the model to pupils in lower and middle primary years

		Reception			Year 2 to 4						All years (original model)					
		Model: Without control R-square = .524 (N=34) ANOVA sig.=.007			Model: Without control R-square = .364 (N=34) ANOVA sig.=.050			Model. Control for ability R-square = .688 (N=34) ANOVA sig.=.001			Model: Without control R-square = .466 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .835 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
Maths attainment (t_o_zma)	asad97	-.331	.081	33	-.144	.463	35	-.223	.141	35	-.256	.024	251	-.337	.001	251
	it_psk	.230	.196	24	.562	.007	28	-.155	.374	28	.512	.000	205	.081	.474	205
	td_97	.479	.012	33	.217	.253	35	.139	.332	35	.351	.002	248	.225	.026	248
	pr_ffl	-.294	.108	31	-.179	.379	32	-.150	.325	32	-.281	.014	116	-.299	.003	116
	zpp							.160	.396	35				.191	.135	35
	zpv							.594	.011	35				.623	.000	35

		Reception			Year 2 to 4						All years (original model)					
		Model: Without control R-square = .728 (N=34) ANOVA sig.=.007			Model: Without control R-square = .465 (N=34) ANOVA sig.=.146			Model: Control for ability R-square = .801 (N=34) ANOVA sig.=.017			Model: Without control R-square = .567 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .877 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
Reading attainment (t_o_zre)	it_psk	.483	.026	24	.495	.084	28	.200	.371	28	.392	.003	205	.087	.523	205
	td_97	.825	.010	33	.249	.361	35	.173	.363	35	.485	.001	248	.315	.031	248
	chl_f3	.812	.002	18	.161	.561	18	.079	.685	18	.419	.004	74	.236	.088	74
	ls_h	-.240	.359	18	.249	.324	18	.270	.145	18	.274	.029	74	.335	.010	74
	zpp							.471	.070	35				.463	.010	35
	zpv							.258	.346	35				.272	.143	35

		Reception			Year 2 to 4						All years (original model)					
		Model: Without control R-square = .823 (N=34) ANOVA sig.=.001			Model: Without control R-square = .419 (N=34) ANOVA sig.=.205			Model: Control for ability R-square = .792 (N=34) ANOVA sig.=.020			Model: Without control R-square = .531 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .890 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
Average maths & reading attainment (t_o_zaa)	asad97	-.339	.037	33	-.095	.716	35	-.193	.293	35	-.248	.056	251	-.339	.007	251
	it_psk	.293	.058	24	.494	.095	28	.092	.681	28	.440	.001	205	.055	.670	205
	td_97	.770	.000	33	.296	.301	35	.224	.257	35	.536	.001	248	.345	.015	248
	chl_f3	.668	.001	18	.154	.601	18	.132	.514	18	.342	.021	74	.157	.213	74
	zpp							.292	.234	35				.326	.042	35
	zpv							.522	.079	35				.506	.010	35

Remark: Multiple regression modes: Method = enter, missing value = pairwise, no collinearity pattern was identified throughout the processes. ***asad97*** refers to the adaptation of programs to make ICT suit those with special needs, ***it_psk*** refers to the percentage of pupils in class who use a computer at home, ***td_97*** refers to teachers' inclination towards the use of ICT in the classroom, ***chl_f3*** refers to the extent of institutional and work related challenges perceived by the teacher in relation to the classroom usage of ICT, ***pr_ffl*** refers to the implementation of teaching practice as a habitual action or routine, ***ls_h*** refers to reflective observation orientation of learning, ***zpp*** refers to standardised scores in non-verbal problems or positions test, ***zpv*** refers to the standardised scores in picture vocabulary test.

Each prediction model in the series had something in common. The regression coefficient (Beta), the statistical significance of the coefficient estimation and the sample size of each predictor were reported in each of the models. The R-square index was the coefficient of determination. It could be used as an index of the percentage of variance that could be explained by the simultaneous work of the group of predictors. The ANOVA was a test of the linear relationship between the independent variables and the dependent variables. Each model was statistically tested for fit with the data. To make the most of the data available, the missing data was treated on a 'pairwise' basis.

The regression coefficient is a measure of the relative importance of an independent variable in predicting a dependent variable. The coefficient could be useful to indicate the consistency of the results when comparisons of the coefficients presented in two prediction models are made. The significance of the coefficient could tell us more about its reliability. For example, when comparing the regression coefficients (Beta) in the three prediction models without control for ability, the discrepancies between the value of the coefficients were not large. The biggest discrepancy was found between the regression coefficients of the variable concerning the percentage of pupils in class using a computer at home (it_psk) in the year 2 to 4 prediction model without control for ability and the regression coefficient of the respective coefficient in the year 2 to 4 prediction model with control for ability. The value of the former was found to be .562 and the value of the latter was found to be -.155. The estimation of the former was found to be statistically significant, but the estimation of the latter was not. This gave the impression that the former was a more reliable estimation than the latter. The impression was supported by the respective coefficient in the prediction model with data from all years without control for ability. Its value was found to be .512, with significance at $p < .01$ level.

Two big discrepancies were found in the series of prediction models for pupil reading attainment. The first pair was between the regression coefficients of inclination towards using computers in the reception year prediction model and the respective coefficient in the year 2 to 4 prediction model without control for ability. The value of the former one was .825, while the value of the latter was .249. The estimation of the former was found to be statistically significant, but the estimation of the latter was not. The second pair was between the regression coefficients of institution and work-related challenges perceived as a results of using computers in the reception year prediction model and the respective coefficient in the year 2 to 4 prediction model without control for ability. The value of the former one was .812, while the value of the latter was .161. The estimation of the former was found to be statistically significant, but the estimation of the latter was not. Both of the coefficients reported in the reception year prediction model were unexpectedly high. The two coefficients were found to be .485 and .419 when data of all the years were taken into account without control for ability.

The measure of pupils' average maths and reading attainment originated from the measures of pupils' maths attainment and pupil's reading attainment. So, the series of prediction models for average maths and reading attainment shared some of the features found in the two series of prediction models. The three pairs of discrepancies identified in the two series of prediction models could also be found in the series of prediction model for average maths and reading attainment. And there is no need to go through each of them again. Instead, it might be worthwhile to note down some of the general patterns of relationships found in the comparisons between these models as below:

1. The results indicated that the multiple regression models without control for ability seemed to be making better predictions than multiple regression models with control for ability.
2. Given that there was close alignment between the present results and the results reported in the proposed model, the present findings confirmed that the proposed model seemed to be reasonably good for predicting learning attainments of primary classes in 1997/98.
3. However, the present findings suggested that the proposed model did not seem to be good enough for making independent predictions of the learning attainments of the reception year and year 2 to 4, respectively.

By checking the significance of each predictor in these models, three of the variables appeared to be significant predictors of learning attainment in reception year. They were:

- the adaptation of programs to make ICT suit those with special needs (asad97) [-],
- inclination towards using computers (td97) [+], and
- the extent of institutional and work-related challenges perceived by the teacher in relation to the classroom usage of ICT (chl_f3) [+].

Further investigations showed that two of the variables appeared to be significant predictors of learning attainment in year 2 to 4. They were:

- the number of pupils in the teaching group or class (aanp97) [+], and
- the planning of specific activities to support any computer programs that the teacher use (apso97) [+].

This would mean that the proposed model could be improved with adjustments in the specification of statistical prediction model could be made according to these features. On this basis, a series of alternative models was formulated.

Illustration I4-2I: Fitness of alternative model

Fitness of the alternative model: Applying the model to pupils in lower and middle primary years

		Reception			Year 2 to 4						All years (alternative model)					
		Model: Without control R-square = .732 (N=34) ANOVA sig.=.006			Model: Without control R-square = .533 (N=34) ANOVA sig.=.000			Model: Control for ability R-square = .725 (N=34) ANOVA sig.=.000			Model: Without control R-square = .430 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .751 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
	asad97	-.340	.078	33							-.262	.026	251	-.319	.010	251
Maths	it_psk	.217	.229	24	.416	.022	28	.109	.500	28	.448	.000	205	.044	.749	205
	td_97	.777	.002	33							.329	.006	248	.227	.063	248
attainment	chl f3	.600	.009	18												
	aanp97				.241	.180	34	.188	.200	34						
(t_o_zma)	apso97				387	.015	35	.245	065	35	.205	.080	251	.059	.616	251
	zpp							.015	.929	35				.172	.274	35
	zpv							.565	.005	35				.611	.002	35

		Reception			Year 2 to 4						All years (alternative model)					
		Model: Without control R-square = .790 (N=34) ANOVA sig =.002			Model: Without control R-square = .606 (N=34) ANOVA sig.=.000			Model: Control for ability R-square = .796 (N=34) ANOVA sig.=.000			Model: Without control R-square = .547 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .877 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
	asad97	-.312	.070	33							-.234	.066	251	-.328	.013	251
Reading	it_psk	.702	.048	24	.390	.020	28	.139	.321	28	.399	.003	205	.073	.601	205
	td_97	.337	.002	33							.561	.000	248	.403	.010	248
attainment	chl_f3	.680	.002	18							.438	.003	74	.255	.073	74
	aanp97				.323	.055	34	.241	.063	34						
(t_o_zre)	apso97				.392	.008	35	.241	.037	35						
	zpp							.307	.037	35				.444	.014	35
	zpv							.302	.066	35				.324	.092	35

		Reception			Year 2 to 4						All years (alternative model)					
		Model: Without control R-square = .823 (N=34) ANOVA sig.=.001			Model: Without control R-square = .642 (N=34) ANOVA sig.=.000			Model: Control for ability R-square = .845 (N=34) ANOVA sig.=.000			Model: Without control R-square = .580 (N=68) ANOVA sig.=.000			Model: Control for ability R-square = .891 (N=68) ANOVA sig.=.000		
D.V.	I.V.	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N	Beta	Sig	N
	asad97	-.339	.037	33							-.278	.029	251	-.342	.010	251
Average	it_psk	.293	.058	24	.429	.008	28	.132	.281	28	.410	.002	205	.056	.675	205
maths &	td_97	.770	.000	33							.518	.001	248	.345	.020	248
reading	chl_f3	.668	.001	18							.376	.010	74	.168	.215	74
attainment	aanp97				.299	.062	34	.227	.045	34						
(t_o_zaa)	apso97				.415	.004	35	.259	.012	35	.230	.071	251	.044	.707	251
	zpp							.168	.177	35				.314	.063	35
	zpv							.463	.003	35				.500	.015	35

Remark: Multiple regression modes: Method = enter, missing value = pairwise, no collinearity pattern was identified throughout the processes. ***asad97*** refers to the adaptation of programs to make ICT suit those with special needs, ***it_psk*** refers to the percentage of pupils in class who use a computer at home, ***td_97*** refers to teachers' inclination towards the use of ICT in the classroom, ***chl_f3*** refers to the extent of institutional and work related challenges perceived by the teacher in relation to the classroom usage of ICT, ***pr_ff1*** refers to the implementation of teaching practice as a habitual action or routine, ***ls_h*** refers to reflective observation orientation of learning, ***zpp*** refers to standardised scores in non-verbal problems or positions test, ***zpv*** refers to the standardised scores in picture vocabulary test.

(4-5-3-3) An alternative model to predict learning attainments and learning gains

The results of the alternative models predicting learning attainments are summarised in Illustration I4-2I. Compared with the prediction models in section 4-5-3-2, the implementation of teaching practice as a habitual action or routine (pr_ff1) and reflective observation orientation of learning (ls_h) were dropped here. And the number of pupils in the teaching group or class (aanp97) was included in the present model. This variable was included because it made a significant contribution when working in the group of predictors, although it was not statistically strong as an independent predictor of the dependent variable in 2-tailed analyses.

Generally speaking, the results suggested that 73% to 82% of the learning attainment in reception year could be explained by the simultaneous work of the variables below:

- the adaptation of programs to make ICT suit those with special needs (asad97) [-],
- the percentage of pupils in class who use a computer at home (it_psk) [+],
- inclination towards using computers (td97) [+], and
- the extent of institutional and work-related challenges perceived by the teacher in relation to the classroom usage of ICT (chl_f3) [+].

The percentage of variance in learning attainments explained was unexpectedly high. If this is true, the results show that teachers in reception year can have great influence on pupils' performance. Compared with children at year 2 and above, children at reception year are at the stage of rapid development growth. They are at an age when they are most willing to learn almost everything. When working on their own learning tasks, it is easy for young children to be distracted by some other unimportant things or events. So, effective teachers of young children need to direct their attention towards the most essential things to be learnt. An enthusiastic and effective teacher is someone who knows what is realistic for the pupils. By setting challenging and achievable learning tasks, teachers can fully exploit the intellectual potentials of their pupils. An effective teacher is also someone who is concerned about institutional and work-related challenges resulting from the use of ICT. As decisions of using computers and not using computers, are made after careful consideration, they can provide children with a positive learning environment on the computers.

When computers are used, they are not used aimlessly. Instead they are used as an extra source of stimulation and motivation to learn. Often computers are used for number work, for practising basic skills and as extended learning activities for children. Computers might also be used as a source of learning reinforcement, for pupils to use when they have finished classwork or to use as part of free choice activities. Nevertheless, learning attainment is positively affected by the pupils' experience in using computers at home. Classes that reported a large percentage of pupils who use a computer at home often had better learning attainments than those reported as having a small percentage. So far, readers should note that the thesis does not under-estimate the effectiveness of the 'self-discovery' method of learning. Instead, given that there were so many things to learn in our life, 'guided self-discovery' is believed to be a realistic and effective way of teaching young children.

An effective teacher in reception year may also be someone who does not want to spend a lot of time in adapting computer programs to make ICT suit those with special educational needs. The results suggest that this is an over-enthusiastic and ineffective practice for all the classes below year 4 because it might divert the teacher's attention from the majority of the class, as reported in section 4-5-1-4c. Furthermore, it would not be difficult to imagine some negative impacts associated with the adaptation of programs to make ICT suit young children with special needs. For instance, the adaptation of the programme might limit their intellectual potential. There might be a labelling effect for these children, which could make them feel that they are academically expected to be not as good as their peers. This would likely to reduce the positive effects of 'developmental pressure' which is one of the main sources of motivation for children with special educational needs.

The results showed that 53% to 64% of the learning attainments in year 2 to 4 could be explained by the simultaneous work of the three variables below:

- the percentage of pupils in class who use a computer at home (it_psk) [+],
- the number of pupils in the teaching group or class (aanp97) [+], and
- the planning of specific activities to support any computer programs that the teacher uses (apso97) [+].

It was found that learning attainment was positively affected by the pupils' experience in using computers at home. Classes that reported a large percentage of pupils who use a computer at home often had better learning attainments than those reported as having a small percentage. And the pattern of relationship would be applied to children from reception year to year 4. Furthermore, the results did not support the expectation that the multiple regression models without control for ability seemed to be making better predictions than multiple regression models with control for ability mentioned in section 4-5-3-2 above. When ability measures were taken into account, the effects of the percentage of pupils who used a computer at home (it_psk) became insignificant. In fact, there were some similarities between the measures of ability and the percentage of pupils who used a computer at home, since both of them were related to home background. So, when considering various measures for raising pupil attainments or the standard of the school, educators in primary education should not ignore the influence of home background.

Lastly, when comparing the regression coefficients in different prediction models, there were some other interesting findings. These included:

- pupils' experience in using computers at home seemed to be a subject specific factor in predicting the reading attainment of pupils in reception year, and
- the teacher's inclination towards using computers seemed to be a subject specific factor in predicting the reading attainment of pupils in reception year.

The two subject-specific factors seemed to suggest that pupils' experience in using computers at home was positively related to their reading attainment and the inclination for their teachers to use computers in school was positively related to their maths attainment. If this is true, the results were not surprising. The usage of computers at home could be different from the usage of computers at school. Home computers could be used for various purposes, including games, education and entertainment. It would be less subject-specific. However, a lot of computer software requires some reading activities, at word level or sentence level. This may include some key words or some instructions presented by the computer. Even when it happens that the child cannot read the text on the screen, it would be easy for a young child using computers at home to get access to an adult for help. The impact on reading attainment is not only the result of using computers at home, but also the attention paid by adults when the child uses computers at home. On the contrary, when computers are used for language activities at school, the usage can be targeted at various language activities. Instead of focusing on developing reading ability of the child, computers are also used for other communication purposes such as listening, speaking and writing purposes. Furthermore, the results in section 4-4-B2 suggest that pupils at lower primary levels had a higher usage of computers for number work than pupils at upper primary levels did. So, it is not surprising that young children with experience in using a computer at home had better reading attainment and teachers with strong inclination to use computers at reception classes had better maths attainment.

The discussion so far implies that, in some instances, it is possible that there are also underlying variables that account for the observed variance. In other words, it is possible that the group of predictor variables acts as a proxy for the underlying variable(s). For example, the results of statistical analysis suggested that a group of three predictor variables (i.e. teachers' personal attitude towards computers, the percentage of pupils in class who uses a computer at home and the number of pupils in the teaching group) in section 4-5-1-3b accounted for 74% of the variance in pupils' performance in picture vocabulary task in 1997/98. It is possible that the group of factors acts as a proxy for the underlying factor(s), such as the pupils' motivation and/or their socio-economic background. Unfortunately, the evidence in the research study was not strong enough to lead to the identification or clarification of the nature of the proxy variable(s). Further investigation, such as an in-depth interview, would be needed for this purpose.

(4-6) Justifications for research design, a summary of findings and discussions

In this section, the author of this thesis is trying to justify the research design and provide a brief summary of the major findings.

(4-6-1) Justifications for research design

1. The results of similar items form the basis for cross-checking and they are complementary to each other.

Each item is a snapshot of an aspect of the research topic. A lack of knowledge could lead to a biased judgement. For instance, the average frequency of class computer usage in 1997/98 was more than several times a week and less than every day. On the basis of this result, a reader may comment that the usage was reasonably frequent. In fact, there is a discrepancy between the frequency of usage and the intensity of usage in terms of the opportunity for a typical pupil in class to access the computer. In the same academic year, the average opportunity for a typical pupil to have a turn on the computer was more than several times a month, but less than several times a week. The correlation statistic between the two items, as presented in Table T4-F1-1, is 0.36. The positive relationship may mean consistency between the constructs of the two items, although the degree of association could be lower than expected. By linking these results together, we would be able to discover that not all the pupils in the class can have a turn on the computer when computers are used in class on a school day. This might lead us to question the reasons or to be aware of the presence of potential problems. For instance, a reader may comment that the lack of equipment is a possible reason for the underlying problem of the waiting time or waiting period for a turn on the computer.

Table T4-F1-1: Correlation statistics between the frequency, intensity and duration of using computers

	ccom97	Pcom97	ptim97
ccom97	-		
pcom97	.36**	-	
ptim97	.20**	.10	-

Keys: ***ccom*** refers to the frequency of class usage of computers, ***pcom*** refers to the intensity of pupil computer usage (i.e. opportunity for a typical pupil in class to have a turn on the computer), ***ptim*** refers to the duration of pupil computer usage (i.e. the amount of time a pupil spends on the computer in a week).

The analysis of relationships between items that bear similar topic focuses can give a better understanding of the topic. It is also an informal cross-checking procedure, as it is in line with the central idea of the "triangulation" procedure in research. Meanwhile, as there is a discrepancy between the item focuses, the findings are complementary to each other. Therefore, the use of similar items not only promotes the reliability of results, but it also enriches our understanding of complex educational phenomena.

2. Justifications of the use of multiple regression techniques and the attention of interaction effects

The present study makes use of multiple regression technique, which uses a group of independent variables to predict a dependent variable. It may happen that an independent variable that cannot function as a significant predictor of a dependent variable when operating on its own is found to be making a contribution as one of the group of predictor variables. The major reason for this is that one variable can interact with the effects of another variable. In other words, the whole is greater than the sum of the parts. It is therefore, more appropriate for us to look at the simultaneous effects of a group of factors, rather than look at the effects of a single factor. On the basis of this rationale, the present study tries to consider the simultaneous effects of pedagogical variables that are related to the use of ICT and pedagogical variables that are not directly related to the use of ICT, and to consider the simultaneous effects of instructional variables, pupil variables and teacher variables. Although it is rare, it is possible that the interaction effects of two positive factors could have a negative impact on teaching and learning!

(4-6-2) A summary of findings and discussion

1. Inferences drawn from the data are useful for us to develop an exploratory understanding of the pedagogical issues concerning the use of ICT

In this chapter, there are variables that are measuring similar concepts concerning the use of ICT, and the interpretation of data helps us to develop a better picture of the whole issue about the use of ICT. For example, the correlation statistics in Table T4-F1-1 also tell us that the amount of time that a typical child spent on the computer during an average week was significantly related to the frequency of class computer usage. It was not significantly related to the opportunity for a typical pupil to have a turn on the computer. This might lead us to infer that the amount of time that a child spent on the computer was affected by the frequency of using a computer in class, but it was not affected by the opportunity for a pupil to have a turn on the computer. As a speculation, the amount of time that a child spent on the computer did not seem to be governed by the intention of maximising the use of available equipment. Instead, it was possible that it was determined by the learning task. Teachers are encouraged to make use of the results, inferences and speculations drawn in this study as a resource for personal classroom investigations.

Furthermore, the results of statistical tests on the internal consistency of measurement scales provide the ground for further analysis. The results are summarised in the table below:

Table T4-F2-1a: A brief summary of the results of statistical tests of internal consistency in this chapter

Description of statistical tests of internal consistency (i.e. alpha statistic > 0.70 is reasonably good)	Results [Further reference e.g. table number]
It examines the internal consistency of a composite measurement scale of teacher IT-skill and 5 measurement sub-scales.	Very good. Alpha statistic of it_tsk98 = 0.96, and those of the other 5 sub-scales ranged from 0.87 to 0.93. [T4-D2-1e]
It examines the internal consistency of 2 sets of 2 measurement scales of curriculum usage of computers.	Reasonably good: 0.75, 0.74, 0.70 and 0.68 [T4-D2-2a]
It examines the internal consistency of 1 set of 2 measurement scales of teachers' inclination towards using computers.	Reasonably good: 0.76 and 0.74 [T4-D3-3a]
It examines the internal consistency of 5 measurement scales of teachers' pedagogical preferences.	Good: ranged from 0.79 to 0.86 [T4-D4-2b]
It examines the internal consistency of 4 measurement scales of teacher reflection.	Fairly good: 0.63, 0.74, 0.73 and 0.66 [T4-D3-3a]
It examines the internal consistency of 4 measurement scales of teacher learning style/orientation.	Good: 0.78, 0.85, 0.87 and 0.89 [T4-D4-2e]

2. The identification of trends or movements helps to prepare for the future

The comparison of data collected in 1997/98 and 1998/99 enables us to identify the trends or recent movements concerning the use of ICT in U.K. primary schools. And the author of this thesis would like to summarise the findings in relation to the findings in section 4-4. To enable the reader to refer back to the discussions above, there is reference information presented in the Table T4-F2-1b below:

Table T4-F2-1b: The results of two-tailed t-test comparing the difference between data collected in 1997/98 and in 1998/99

Reference & variable name (in brief)	Significant findings at p < .05 i.e. unless specified, there was a significant difference. Here are the features associated with the recent data:	Not significant with p > .10 i.e. there was no significant difference:
(4-4-A2) Equipment provision	• data variables are not available for comparison	
(4-4-A3) Planning computer activities	• increase in planning specific computer activities for pupils with special needs • increase in adapting the use of programs to suit those with special needs	• in other variables in this section
(4-4-A3) weekly plan	• most data variables are not available for comparison	• in specifying ICT in weekly planning
(4-4-B1) it skills & exposure	• data variables are not available for comparison	
(4-4-B1) amount of usage	• increase in the frequency for a typical pupil in class to have a turn on the computer • more time in using computers	• in frequency of class usage
(4-4-B2) computer use		• in teachers' curriculum use of ICT i.e. for presentation • in any type of pupils' curriculum use of ICT
(4-4-C1) challenge of using ict	• data variables are not available for comparison	
(4-4-C2) perceived effects of ICT	• data variables are not available for comparison	
(4-4-C3) inclination to use ICT	• increase in teachers' knowledge about parents' supportive attitude towards educational use of computers • teachers are less keen on the educational use of ICT	• in other variables in this section
(4-4-D2) pedagogical preference	• data variables are not available for comparison	
(4-4-D2) Learning style	• data variables are not available for comparison	
(4-4-D2) Reflective practice	• data variables are not available for comparison	

Remark: As the trend/recent movement is represented by comparing two points of time, the generalisation is subject to the threat of instability. So, an "increase/decrease" or "more/less" in a specific aspect above can be interpreted as "higher/lower" in a specific aspect in 1998/99 than in 1997/98.

For educational development, findings of multiple regression models could be useful for planning interventions. Path coefficients are useful reference for showing the relative weighting of a specific factor among the group of identified factors. It would be useful to check if the trends or future movements is a healthy growth, towards a balanced weighting for promoting a specific effective teaching and learning outcome.

3. Attention has to be paid to the difference between levels of primary education or year groups. When planning for interventions, educators need to check if the generalisation is applicable to the target group.

The data collected in 1997/98 or 1998/99 has enabled us to identify differences between levels of primary education. The information is important for establishing the scope and limitations of the present findings, as well as useful for the planning and intervention. And the author would like to summarise the findings in relation to the variables in 1997/98 in Table T4-F2-1c below. It shows the aspect of change of a specific variable in relation to upper levels in primary education:

Table T4-F2-1c: The results of two-tailed ANOVA comparing the difference between pedagogical and instructional practice in lower primary and in upper primary

Reference & Variable name (in brief)	Significant findings at p < .05 i.e. there was a significant difference between upper and lower primary levels. Here are the features associated with teaching groups at upper primary levels:	Not significant with p > .10 i.e. there was no significant difference between upper and lower primary levels:
(4-4-A2) Equipment provision	• more computers available for pupils to use and more hardware/software add-ons • better provision of ICT equipment	• in the number of internet access points for teachers or for pupils between different levels of primary education
(4-4-A3) plan computer activities	• increase in the number of pupils in class, the planning of specific computer activities for pupils with special needs, the adaptation of programs to suit for those with special educational needs, the number of pupils on the special needs register at Level 3-5 and the regularity of having other adults helping teachers in class	• in other variables in this section between different levels of primary education
(4-4-A3) weekly plan	• increase in the number of IT co-ordinators	• no other data variables in 1997/98 is available for comparison • no significant difference in the number of maths and literacy co-ordinators between different levels of primary education in 1998/99
(4-4-B1) it skills & exposure	• increase in the percentage of pupils in class who use a computer at home • increase in teachers' self-rated IT skills	
(4-4-B1) amount of usage	• decrease in the frequency for a typical pupil in class to have a turn on the computer • significant difference in the duration of time in using computers, i.e. 25 mins. at level 1, 21 mins. at level 2 and 36 mins. at level 3	• in the frequency of class usage between different levels of primary education

(4-4-B2) computer use	• increase in the curriculum use of computers at playtime, for information retrieval and for word processing • decrease in the curriculum use of computers as an extension work, for practising basic skills, for number work, as a free-choice activity and when pupils have finished work	• in other aspects of curriculum use of computers
(4-4-C1) challenge of using ICT	• decrease in the practical challenges for reliable equipment, technical support and additional supports for pupils	• in other variables in this section between different levels of primary education
(4-4-C2) perceived workload	• increase in workload as a result of using ICT to support subject teaching	
(4-4-C3) inclination to use ICT	• teachers at level 3 has a higher agreement on the statement "I think the educational use of ICT is cost-effective" than those at level 1 and 2 • increase in the agreement on the statement "most software is too complicated for my pupils to use"	• in other variables in this section between different levels of primary education
(4-4-D2) pedagogical preference		• in these variables between different levels of primary education
(4-4-D2) Learning style		• in these variables between different levels of primary education
(4-4-D2) Reflective practice		• in these variables between different levels of primary education

To conclude, the above examples tell us that the pedagogical use of ICT has close relation with the non-ICT based pedagogical instruction. In referring to the aim of the tasks, effective pedagogical arrangements with the use of ICT will depend on pedagogical considerations on both sides, their interactions as well as variables of individual differences e.g. age, sex, learning styles...etc.

Summary of Chapter 4

- In large classes, the teacher's workload for using computers is increased and the opportunity for pupils to have a turn on the computer is reduced, and vice versa.
- Teachers of those classes with more SEN children tend to avoid the use of ICT in their weekly plan.
- On average there were two computers available for each class in the teacher survey in 1997/98. The average number of pupils per computer was 19, which was not significantly different from the national average. The results of descriptive statistics showed that the functionality of their equipment was better than that of the national average. The pupils in lower primary had fewer computers available for use, and vice versa. No significant different in the hardware and software add-ons (peripherals) between different primary levels were found.
- In the academic year 1997/98, the average frequency of class usage was more than 'several times a week', but less than 'every day'. The opportunity for a typical pupil to have a turn on the computer was more than 'several times a month', but less than 'several times a week'. The duration of time that a typical child spent on the computer during an average week in 1997/98 was 28 minutes.
- From 1997/98 to 1998/99, an increase in the extent of computer usage was found at pupil level (i.e. the frequency to have a turn on the computer), but not at class level. This implies that the increase in provision of computer equipment only increased the opportunity and the amount of time for pupils to use the computer, while no significant change was brought to teacher's pedagogy concerning its use for pupil learning. The exception was an increase in the use of computers to demonstrate something to the whole class.

- An average of 28% of the selected pupils used a computer at home. A higher percentage of upper primary pupils used a computer at home than that of lower primary pupils.
- Teachers' inclination towards using computers was negatively related to the extent of challenges perceived by them. Simply encouraging teachers to use computers would not be an effective strategy to promote their use. To promote the use of ICT, extra attention has to be paid to non-psychological factors such as providing teachers with training in IT knowledge and skills, reducing their work duties and workload, and providing technical, financial and human resource support.
- Computer activities for upper primary children were relatively academic and intellectually demanding. Computer activities for lower primary children were relatively relaxing. They could be part of the pupil's free choice activities, and they could be used as a form of supplementary work to do when the pupil had finished their formal class work. This is a possible explanation for the finding that teachers in upper primary had a higher perceived workload resulting from the use of computers.
- Teachers' inclination towards the use of ICT in the classroom seemed to be an important factor that positively affected pupil academic attainment and academic learning gains. Older children in primary education seemed to spend a longer time on the computer, but they had less chance to get a turn than pupils in lower primary education.
- A path model showing the impact of some ICT-related factors on learning outcome is formulated. The validity of the model is verified by applying it to predict learning attainments of pupils at lower primary and upper primary, respectively. The chapter concludes with a revised model.